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PLATE I.

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THE *PSYLLA* DISEASE OF INDIGO IN BEHAR.

BY

H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S.,

Imperial Entomologist.

Psylla on indigo in Bengal was recorded in Indian Museum Notes as occurring in July 1890, the indigo crop in Bengal having been reduced about one-third according to an estimate made by Messrs. Jardine, Skinner & Co. Young insects which were then named *Psylla* [illegible] It is known [illegible] sent to Pusa in 1905 from South Arcot, and [illegible] Cawnpore, where it has been found this year.

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PLATE I.

THE *PSYLLA* DISEASE OF INDIGO IN BEHAR.

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Psylla on indigo in Bengal was recorded in Indian Museum Notes as occurring in July 1890, the indigo crop in Bengal having been reduced about one-third according to an estimate made by Messrs. Jardine, Skinner & Co. Young insects which were then named *Psylla isitis* were found on affected shoots. It is known also to occur in Madras, specimens having been sent to Pusa in 1905 from South Arcot; and in Cawnpore, where it has been found this year.

In 1907, it was abundant in Behar and a report was prepared and circulated among members of the Behar Planters' Association. In this report, it was stated that *Psylla* was probably indigenous to Behar, was no new insect from elsewhere, and the question of why in 1907 it should be excessively abundant was discussed. Two alternatives were suggested, one that the weather had been unusual and favoured it, the other that the cultivation of Java plant throughout the year had favoured it, as it lived and bred all the year on the indigo sown in September or on the plants left standing in October for another year. It was also pointed out that if the outbreak was due to weather, it would pass off, if due to the altered way of growing indigo it would grow worse. The 1907 outbreak was put down to a combination of both causes and, in the light of subsequent events, probably this was only partly correct, weather conditions having nothing to do with it. (Agricultural Journal of India, Vol. II, p. 384.)

Information was collected in 1907 by the Behar Planters' Association as to the prevalence of *Psylla* on factories and the Managers of many Concerns were good enough to send in information. In 1908, the pest was reported to Pusa from Benipore, Sakri and from Kooria, Bettiah. In 1910, it was reported from Ilmasnuggar, Samastipur and from Nawadah Seeraha. In 1910, it appears not to have been general as information was asked for and only two Concerns reported it. In 1911, it was reported from only a few Concerns, but was doing serious damage, and in November the General Secretary, Behar Planters' Association, wrote to the Inspector-General of Agriculture, referring to "disease" in the koontee crop and estimating the loss at Rs. 15,00,000. This loss was not attributed directly to *Psylla* but partly to *Psylla* and partly to what were believed to be fungoid diseases.

At the present time, indigo is growing in Madras, in the United Provinces and in the Punjab on the old system which prevailed before Java was introduced: in these places, *Psylla* occurs and its parasite; no new parasite has been found, but in these places *Psylla* has not assumed the large proportions it has in Behar, nor is it a serious pest; it occurs there as it did in Behar before Java was introduced, on a small scale and completely kept in check by natural causes. The reason it has remained as a serious pest to Java indigo since 1907 is, I believe, entirely due to the change in the method of growing indigo; all the available evidence supports this view and there is nothing unreasonable in it.

Existing Diseases.—The Java indigo plant at the present time differs markedly from the plant grown in 1905-1906 when Java was first introduced. This difference is shown clearly both in koonties and in moorhun plant kept for seed. Almost everywhere in Behar, there is a very great decrease in the yield of koonties, due to their poor growth and to the loss of leaf. Two distinct sets of conditions are noticeable. In the first the plant grows weakly; some of it dies, the leaf drooping, withering and turning black, the shoots die completely; this occurs in koonties sporadically or in blocks, and affects mostly quite young shoots

on plant that has been cut late. It occurs rarely in moorhun plant. Much more of the plant presents different symptoms; the leaflets become crisp, curl longitudinally towards the mid-rib, turn yellow and fall off; instead of a long growth of green leaves one finds a small cluster of foliage at the tip of the shoot, the leaflets frequently being very small and yellow; eventually these shoots dry up; in many cases fresh green foliage grows at points on the stems, but this does not fully develop.

These two appearances of disease appear to be distinct; they may occur on the same plant; they may occur on koontie or moorhun plant; but, on the whole, there is comparatively little of the black wilting and a very great deal of the yellowing. So far as my observation during three months this year shows, the loss of plant in koonties and the failure of either koonties or moorhun plant to produce seed is almost wholly due to the latter condition which we may, in the absence of a name, call X. The terms Wilt and Charybdis have been used to designate this condition of the plant; "wilt," if used at all, should be reserved for the condition when the leaves become flaccid, turn black and dry up, not for the condition we designate X. The term Charybdis is misleading, as the disease follows *Psylla* in time but not as a consequence.

There is a further definite condition of the plant, which has been produced by the presence on the plant of *Psylla;* in this condition, the leaflets curl irregularly, the tender apical shoot ceases to grow straight but curls into a compact knot with the leaflets; almost always it is only the tip of the plant which is affected; in some cases curled leaves are found a little way from the apex, due to the leaflets only having been affected and the shoot having grown through and formed healthy leaves beyond; this condition is characteristic either of a light attack on the leaves only or of an attack which occurred some time before, from which the plant has recovered. If the *Psylla* remains long on one shoot, growth ceases entirely, the tip dies, the leaves fall off and side shoots come out. In the insectary it has been

possible to kill the terminal shoot with heavy infections of *Psylla*, but this rarely occurs in the field.

At the present time only one definite organism has been found on indigo: this is the insect *Psylla*. It has been supposed that all the above symptoms of disease are connected with *Psylla*, but I am convinced that this is not so. The presence of *Psylla* has no direct connection with any disease symptom except the curling of the tips and leaves, and other causes have to be sought for the more serious effects produced. The reasons that lead me to this belief are:—

(1) Java indigo growing at Cawnpore has *Psylla* but shows no other disease symptom than those mentioned as due to *Psylla*.

(2) Plants grown in the insectary and well infected with *Psylla* do not show symptoms of either of the other diseases.

(3) There is not in the field any correlation between abundance of *Psylla* and large loss of plant from wilt or X. If *Psylla* was connected with either, one would find a correlation between abundance of *Psylla* and large loss of plant from wilt or X.

(4) Plant growing in the field, and showing all forms of disease, if kept free from *Psylla* by spraying, does not show any less increase of X than plant in which *Psylla* is not checked.

(5) Sumatrana indigo is heavily infected with *Psylla* but does not exhibit symptoms characteristic of X.

(6) The localised occurrence of X on individual shoots bears no relation to the relative occurrence on these shoots of *Psylla*.

I have very carefully examined indigo growing at a number of Concerns in Behar during August, September, October and November 1912, and I am convinced that there is no direct connection between the occurrence of *Psylla* and the amount of wilt or of X present. I believe that the very great loss in indigo is due mainly to X; the occurrence of X does not seem to be correlated with any general characteristic of soil drainage, method of cultivation, treatment of the plant or crop rotation which can be found by observation; X develops from August onwards in

increasing amount in both koonties and in moorhun plant; it develops just as much in plant infected with *Psylla* as in plant freed from *Psylla* by spraying or in plant in which *Psylla* is almost absent. I have seen no plant in Behar absolutely free of *Psylla;* the Sirsiah plants which have been individually under the very closest observation have developed X quite independently of the relative amount of *Psylla* on them; plant grown at Pusa under different conditions has developed X in all cases; there does not appear to be any connection between the foulness of the land or the cleanness of the land and the occurrence of X, and my belief is that in both wilt and X there is an organism or a definite physiological cause completely independent of *Psylla.* I treat *Psylla* therefore as being the direct cause only of curling of the tips and leaves, with a checking of growth, leading to a decreased weight of cut plant and to a small decrease in the seed yield.

The main factor in the failure of the plant to seed is the great increase of X in the plant from August onwards; *Psylla* checks the growth of the shoot; it does not cause the leaf to turn yellow, or to fall off, nor does it lead to the very extensive death of plant which occurs during October—November. It is clearly a far less important factor than is X, but it is still a factor that cannot be neglected. Fortunately it is a clear definite pest, whose behaviour can be studied and which can be checked without great difficulty. Its position in regard to indigo is quite clear; it behaves exactly like other insect pests and there is no room for doubt as to what it does. It causes certain definite symptoms in the plant, its abundance is due to quite definite known causes and it is possible to put down accurately exactly the part it plays in regard to the cultivation of indigo.

The inquiry this year has shown that we have to look to more than *Psylla*, and while *Psylla* is important, the degeneration of the plant generally, the occurrence of the disease X, the failure of koonties and seed plant are very much more important. If these problems could be settled, if the plant could be got back to the vigour it first showed, indigo

planters would be in a very much better position. The occurrence of the disease X in the experimental plant at Sirsiah has ruined the work that was being done there, and until the problem of this disease is settled, it is unlikely that any progress can be made there. If it had been a question of *Psylla*, it would have been all right, but it is unfortunately not and, if this inquiry has no other result, it has done good by bringing forward the enormous importance of the disease-conditions X and their influence on the indigo crop.

Effect on the Plant.—The effect of *Psylla* on the plant is well known to planters: it differs in the Java and Sumatrana plants owing to their different habit and structure; the Java tip curls into a very compact hard knot owing to the thick stem and the crowded leaves (plate II, fig. 2); the long slender stems of the Sumatrana with their leaves well spread out curl into less compact masses. (Plate II, fig. 4). Curling is caused by the action of one or more nymphs, commencing usually after two days from the time the nymph is put on the plant. In no other way has curling been produced, and though there are other insects on the indigo, the curling is the direct result of the *Psylla* nymph sucking the shoot or leaf. Neither the Aphid nor the Jassid, common on indigo, produce curling. Curling is not permanent; a plant was infested with nymphs (5) on the 17th February and curling appeared on the 22nd. By the 1st March all the nymphs had become adults and the plant was free. It was healthy, the shoot had grown well and there was no sign of curling by the 29th March. Curling is not caused by the adult form: a plant was infested with five adult females that came out on the 22nd February; one escaped; two died on the 26th March, one on the 28th March, one on 29th March. They laid more than 800 eggs none of which hatched (there had been no mating). The plant showed no signs of curling. It is worth noting that whilst in 1907, Sumatrana was more attacked than Java, the reverse is generally the case now: it seems that the nsect finds conditions better on the Java plant, mainly, I think, because of the more compact curl produced and so has accus-

PLATE II.

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A. J. I.

Figs. 1 & 2. Java plant, normal, and curled by Psylla.
,, 3 & 4. Sumatrana plant, normal, and curled by Psylla.

tomed itself to that plant and goes less to the Sumatrana; in addition, the actual damage done to the Sumatrana plant is very much less than to the Java, owing to the different habit of the plant.

Life History of Psylla.—(Plate I). The *Psylla* hatches from eggs laid by the female on the plant and the following are the more important points of the life of the insect :—

Eggs are laid singly, stuck to the plant; they are laid near the tip of the shoot if there is room, either on the stem itself, or on the leafstalks or the leaflets. Each egg is cylindrical, tapering to each end, one end a little broader than the other; when first laid they are very pale yellow, almost white; in two days they become deep black.

The egg bursts at one end and there emerges the young *Psylla*; when it has got clear of the egg-shell, it walks away. In this form it is called a "Nymph :" it lives for a number of days growing larger; at intervals it has to moult, casting the complete skin; this moult allows for growth in size, and also allows the wings to develop. There are five such moults at intervals of 2 to 5 days; at the last moult the fully grown insect appears, able to fly and also able to reproduce. The male is a little different to the female in appearance, smaller and slightly browner. Until the last moult is completed the insect cannot fly; it can only crawl; it spends its time on the tip of the shoot or on the leafstalks or among the curled-up leaves; it feeds by sucking the juice from the soft plant; and until it gets winged, it endeavours to spend its whole time in concealment among the leaves where it may obtain food and be sheltered. It is flattened, with long legs, and its general appearance is best seen from the plate; in the first stage it has no signs of wings, but the wings gradually develop as lobes on the sides and one can tell the stage of development from the size of the insect and of the lobes. In colour it is of a yellowish tint, with the winglobes getting brown; the larger forms may be greenish.

If eggs are laid by the adult on a plant completely free of *Psylla* and these hatch, curling of the tip will commence after

two days; the nymph alone causes curling and it has only to be on the plant for two days for curling to commence. The nymph is so flat that it can live singly in the tightly-folded leaves of the crumpled top ; it is nearly as flat as the common bed bug and has similar habits with regard to the plant that this insect has with regard to man. The fully grown winged form is not flattened, is more active, flies about, and may be seen sitting on the leaves or shoots ; it does not cause curling and there is nothing to show if it is on the plant or not, unless it is actually seen. The females can begin to lay eggs in three to four days after they have become winged, and lay eggs during eight to twenty-six days ; they may live longer but usually die in about fourteen days after emerging ; the males die sooner.

The total life is as follows : the eggs are laid and hatch in from 5 to 10 days ; the nymph feeds and develops in the shoot, causing it to crumple, it has five moults, spends over 12 to 20 days and then becomes winged, in four days the males may be dead, the females commence to lay eggs. In the laboratory, adults, both male and female, have lived up to 39 days on indigo. The total period of a generation is from 23 to 33 days ; the shorter periods are in the hot weather, the longer in the cold. In the coldest part of the winter there is one generation that occupies at least two months.

This sequence of events is the normal one when there is indigo growing : when there is no indigo, it is uncertain if the adult *Psylla* can live on other plants or can remain alive without food indefinitely. It is certain that it remains alive as an adult, feeding on other plants but not laying eggs on them. That is, the only stage in which it lives over when not on indigo is in the adult condition. This is also the only stage in which it moves about ; the nymph, if removed from the plant, can crawl, but ordinarily will not move out of the crumpled leaf unless compelled to.

It is necessary to realise clearly that there are thus two distinct forms of *Psylla* : the egg and nymph forms which are passed on the indigo plant and only there, and which are not

prolonged for more than 20 days in warm weather; and the adult winged form which is independent of indigo except for egg-laying, which flies about, lives on other plants and is not limited to a life of only 20 days.

During this season, it was noticed that some *Psylla* nymphs behaved differently to the rest; instead of remaining in the closely curled top, they migrate down the stem and fix themselves in a colony at one spot; this was observed by Mr. Parnell at Sirsiah; it was then noticed at Pusa and colonies were kept under observation.

When a nymph is parasitised, *i.e.*, contains the parasite grub that is destroying it, it has this habit normally but each nymph is solitary; in the above case of colonies some of the nymphs might be parasitised but not all; and some colonies consisted of unparasitised normal nymphs which developed normally to winged adults. This peculiar habit was noticed only in September-October this year, it may be connected with some condition of the plant or with the very heavy fall of dew that set in this year in the middle of September.

Rate of Increase.—Individual females have been found to lay eggs numbering respectively 274, 314, 572, 208, 710, (31), 828. The normal rate of increase we may take to be somewhere between 200 and 800, say 500; *i.e.*, if there is a fresh generation every month, a pair of *Psylla* would increase as follows:—

1st January	... ...	2 *Psyllas*	lay	500 eggs.
1st February	... ...	200 females	,,	100,000 ,,
1st March	...	40,000 ,,	,,	20,000,000 ,,
1st April	...	8,000,000 ,,	,,	40,000 millions.

This is assuming 400 out of 500 to live to the adult state and of these 200 to be females that mate. This does not occur probably in Nature and there is not normally this actual rate of increase; but something approaching it might occur if indigo was sown in a fresh place surrounded by other crops and one fertile female flew into it from a distance.

Food Plants.—*Psylla* feeds and increases normally upon cultivated indigo; Prain states that both the present cultivated indigos are introduced plants: there is reason to believe that *Psylla* is an indigenous insect to India, and that it took to growing on indigo when that was cultivated. In that case one would expect that *Psylla* bred upon some wild plant either on indigo (*i.e.*, *Indigofera*) or possibly some plant, not allied to indigo, but containing the substance indican. Prain mentions one species of *Indigofera* as occurring wild in Behar; *Indigofera linifolia*, a small weed in lawns and pastures.

Trials have been made of some of these to see if *Psylla* will feed or will breed on them. With *Indigofera linifolia* and *I.* (?) *tinctoria*, no success was obtained. With *Indigofera oligosperma*, *I. pauciflora* and *I. anil*, the nymphs would feed and develop; they are not wild species in Behar however.

These points are important in view of the occurrence of *Psylla* on new lands: it is almost certain that *Psylla* has a wild food-plant in Bengal; this plant may be rare in Tirhoot; we have not found it though we know of two plants other than indigo on which the *Psylla* nymphs will develop; whether we find it or not is immaterial, as *Psylla* may have now entirely forsaken it and adapted itself to cultivated indigo.

It is necessary also to emphasise the fact that in this question of food-plants I am considering those on which the insect multiplies, that is, on which the adult lays eggs and on which nymphs come to maturity; the food-plants of the adult are probably wider and not restricted in this manner. It is thought that *Psylla* reappears mysteriously after floods and also is found unaccountably on lands sown for the first time with indigo, for instance, on clean lands far from cultivated indigo. We know of no stage in which the insect can wait except the adult, we know of no limit to the distance it might be blown, be carried by birds, men or carts, and we have no reason to doubt that female *Psyllas* might in flood go to the tops of trees, and descend again to lay eggs upon indigo after two or more months. When one *Psylla* can produce 600 curled

tops, it can be seen that not many are required to make a visible effect.

Any one interested in this point must remember that it is the winged *Psylla* that is to be looked for off indigo and not curled leaves produced by nymphs.

The distance travelled by winged *Psylla* is not known. Indigo sown in a field in Pusa in November was infected early in February ; there had been no indigo cultivated in Pusa for over 18 months and the nearest was not less than a mile away. It probably took days or weeks to travel this distance.

Psylla occurs everywhere in Behar, I have sought in vain for any indigo completely free, even in fields situated as much as seven miles from any other indigo. On new land never before in indigo and miles from any cultivation of indigo, *Psylla* appears the first season.

Attempts have been made to find the plant on which the winged *Psylla* lives over the winter if there is no indigo or on which it lived before Java was cultivated. It must be remembered that *Psylla* will feed on various indigos, though not on the commonest wild indigo ; and trials have been made with a long series of common plants to see how long adult *Psylla* will live on them. In captivity, *Psylla* will live for forty days on indigo ; on no plant except the above has it lived longer than four days. It is impossible to test all the plants of Behar in a short time ; we have not hit upon its food-plant as yet, but it clearly has one, unless it finds sufficient indigo growing in odd corners or finds sufficient *Tephrosia purpurea.*

Psylla and Sumatrana Plant.—Prior to 1905-1906 or thereabouts, Sumatrana was the indigo grown ; it was in the land from March to October ; from November to March the *Psylla* was in the fields in the winged adult form waiting through the winter. I make this statement deliberately on the evidence available as to its habits, not because I have ever personally seen it. I believe that if indigo was again grown on the old system the former state of things would return and *Psylla* would cause only minor damage, but I do not think that that state of affairs would

be restored at once. This means that seed cultivation could not be done in Behar and that under no circumstances should indigo be grown from November to March.

How Psylla spends the year.—Reviewing the behaviour of the pest through the year, we may briefly state that it behaves as follows : in December-January there are usually winged adults with some nymphs waiting in the young Java or in plants standing over for another year : these breed in March or earlier, this probably varying with the character of the season. From March onwards, the breeding appears to be slow, either because the climatic conditions are unsuitable or because there are checks at work then which later become less active. In June-July the crop is cut ; cutting occupies from four to six weeks ; and there are two ways in which this period is got through ; where a field is not completely cut or there is standing indigo alongside, those *Psyllas* that can, go over to these plants ; a number live over on the stumps until these sprout ; where there is no indigo near, and the stumps are covered, all but the winged ones perish and those winged ones, that can reach other indigo, do so by flying ; if not they live over on other plants till the indigo grows again. When it grows again, the winged ones enter it and start egg-laying. Breeding then goes on very rapidly until November when the cold weather checks its rapidity, and the adults, as they become adults, tend to live over without breeding until February.

From the point of view of checking the pest, we must direct our attention to this period when the indigo is cut. I return to this point below.

Enemies.—*Psylla* has, like other insects, enemies which feed upon it or otherwise destroy it. We know definitely of three Ladybird Beetles *(Coccinella septempunctata, Chilomenes sexmaculata, Brumus suturalis)*, a Chrysopa *(Chrysopa alcestes)* and a Syrphus *(Pelecocera* sp.*)* which do so and there is a Mantis *(Hierodula westwoodi)* and a Spider. These actually eat the *Psylla* nymphs : they also eat other insects, and the question whether they attack *Psylla* or not depends probably largely on the presence or absence of other insects they feed upon. There

is, for instance, an Aphis on indigo which they also eat and there are other insects on other crops which they feed on. There was, for instance, no Aphis on any of our indigo before 5th May. On 1st July Aphides had already appeared. After that Aphides have gone on increasing and most probably diverting the enemies from *Psylla*.

There is also a parasite, that is, an insect which lays an egg in a *Psylla* nymph, this egg developing inside the *Psylla* nymph and destroying it. This insect does not attack insects so varied as the others do and is a more direct check upon *Psylla*. It destroys only the nymphs : it lays an egg in the nymph : this hatches inside to a grub, which absorbs the nutritive matter in the grub and slowly kills it ; before it perishes, the nymph comes out of the curled top, fixes itself on the stem and dies, turning brown and forming a case for the parasite grub to pupate in.

The presence or absence of these insects very largely determines whether *Psylla* is abundant or not ; and if one considers the rate of increase of *Psylla*, its dependence upon the indigo plant, the action on it of climate, the effect on it of some six or more different enemies, one can see that the problem of why *Psylla* is at one season or another abundant or scarce is a complex one. In nature, as a rule, checks (*i.e.*, enemies and parasites) tend to balance the natural increase of an insect and to keep it down to a level, which varies a little but never admits of an enormous increase of the insect ; this balance is delicate and the change in the method of cultivation of indigo has upset it ; the result is too much *Psylla* and it is a question how long a period will elapse before the balance again adjusts itself, before the enemies adjust themselves to new conditions and are able to again cope with the increase of *Psylla*. I have put it very crudely but I believe approximately correctly.

What happens at Cutting.—I now return to the important moment when the crop is cut ; if this is properly done, the *Psylla* is suddenly checked ; nearly all the nymphs are carried off with the plant ; mainly winged adults are left which sit on the stumps

and there is, for some time, no young *Psylla* for the Ladybirds and other enemies to feed on. These enemies go to other crops, *e.g.*, *makai*, and feed on other insects. When the crop grows, *Psylla* is there, the enemies are not there and the *Psylla* for some time breeds unchecked. This brings about (1) the absence of *Psylla* on koonties at first, (2) the subsequent enormous increase of *Psylla* during July and August unchecked by enemies, which only again get a hold of it by September.

The only enemy that is probably limited to *Psylla* is the parasite; it probably waits and attacks *Psylla* again soon; it is, however, not so important a check as the *Syrphus* and appears not to be able normally to check *Psylla*.

It is now known that the nymphs can live on the stumps. The grown-up nymphs (4th and 5th stages) have also been found able to crawl over a distance of more than 5 feet. Very few, however, fall off the green plant when it is cut; almost all are removed to the vats, with their parasites in them if they have any. It is certain that all these nymphs, which fall off on fields, do not die, if the plants are not properly cut to the ground; if any shoots are left uncut, some certainly live on these and others live on the cut stumps if these are left exposed. But without food all die within two days.

Conditions in 1912.—In the past we have only had general observations to rely on, going back to 1907 and mainly made at Pusa and Sirsiah. From the beginning of August 1912 to the middle of November, the crop was very closely studied and an endeavour made to grasp the problem. A number of Concerns were visited, some at regular intervals to watch the progress of the outbreak. Also a number of Concerns sent in "curly tops" containing *Psylla* from which we bred any parasites that were in the nymphs.

On the whole, there was much more *Psylla* during August than during September; in almost every case the attack of *Psylla* was worst in July-August but decreased to some extent during September. This recovery was far more marked, for instance, in Motipur, Tatareeah and the neighbourhood than in

Dholi, Mia Chapra and Hursingpur. At the same time this difference was not widespread: Seeraha in September was so bad as to benefit from spraying; Dholi made a recovery during the beginning of October. On the whole, the amount of *Psylla* lessened as the monsoon wore on to its close and I attribute this partly to the increase of parasite but, far more, to the increase in the amount of insects that fed on *Psylla* during September, due, I believe, to the ripening of the *makai* crop. The *makai* had Aphides on which these enemies fed, and when the first indigo cutting was made, these enemies seem to have gone to the *makai*, to return later to the indigo. I attach less weight to the parasite now as in no case was it sufficiently abundant to dominate the *Psylla*.

I attach great importance to the value of checking the *Psylla* early; if we could prevent the great increase which takes place while the *makai* is growing, we could probably keep *Psylla* within limits. The varying conditions of Behar amply account for the variation in the amount of *Psylla* from place to place and if we could have traced all the enemies of *Psylla* through the season, we should be able to see why *Psylla* was less checked in one Concern than in its neighbour.

The Managers of a number of Concerns were good enough to send in information and "curly tops"; I was also able to visit a number of Concerns and to obtain the views of Managers on the disease. The information obtained and the conclusions arrived at are embodied in this report and there would be no useful purpose in discussing this in detail. It is clear that the conditions of *Psylla* and its occurrence are not uniform over a whole district and that they vary from one Concern to another: it will pay every Manager to watch the occurrence of *Psylla* on his lands, and I believe it would pay him to make certain that he had parasite present directly he got evidence of an attack beginning in the koonties in July; this is best done by sending 100 "curly tops" to Pusa and if no parasite is found getting it through Pusa.

The Plant.—In my previous note, I stated that a strong plant was less affected by *Psylla.* I am inclined to attach less weight to that now as I have seen very healthy vigorous plant suffering heavily from slight infestation of *Psylla.* The plant at Sirsiah manured with superphosphate was bigger, robuster and more vigorous ; yet we were unable to detect by observation any marked difference in the number of curled heads in the plots. So also at Pusa where there was plant of different ages, some cut, some uncut, some well cultivated, some badly cultivated. Where koonties and moorhun plant stood side by side, the amount of *Psylla* in the koonties was much greater than in the moorhun plant, due to the winged adults migrating ; they evidently prefer the low plants, possibly as being more sheltered.

Summary.—To sum up, I regard the present outbreak as the natural consequence of that of 1907 ; the change of cultivation has upset conditions ; *Psylla* is unduly abundant and may remain so for some time ; the difference in the amount of *Psylla* at different places is quite understandable ; and we have to concentrate our attention on three points : can we restore the previous condition ; can we do anything to directly check the present outbreak ; can we find any remedy capable of immediate application.

Preventives.—In regard to preventives for the present attack. I would strongly urge that every Planter does what he can to carry out thoroughly four things :

(1). To cut every plant level with the ground if possible, but if a stump must be left, to leave no green leaf or shoots.

(2). To cut most carefully every plant, never leaving even one odd uncut one.

(3). To cut over as big a block of lands at once as possible.

(4). If possible to plough and hanger the crop after cutting.

I look on these as the most important things and I recognise the difficulties there are, particularly in the third. But if every Planter did what he could in these things, there would be less *Psylla*, and every man who does them will individually reduce the *Psylla* on his own lands. It is definitely known that indigo is

infested quite early; a small plot was sown in the second week of May 1912 in Pusa and was well infested with nymphs and had curled heads before July 3rd. So it may be also after cutting; a plot was cut on 12th July, every scrap of green being removed; it was re-infested and eggs laid by 28th July and curled heads were to be seen by the 31st July. This plot was perhaps 50 yards from another. In the fields of indigo that had been cut and had sprouted, eggs were found on plants that were surrounding odd plants left uncut; these plants were infested and the *Psylla* adults had clearly moved over. In such cases infestation of koontie plants will be much more rapid than if all plants had been very thoroughly cut.

If when 20 bighas of plant are to be cut, this can be done in a compact block of lands, not in that block omitting any plant at all, those lands will improve. I know it cannot always be done, but I think there would be much less *Psylla* if Planters kept it in mind and did the best they could.

The Future.—It is certain that *Psylla* will remain a pest so long as Java is grown on the present system; I see no likelihood of things altering, and so long as there is indigo in the land all the winter and the first cutting is made in June, there must inevitably be an outbreak of *Psylla* in July-August. It is necessary to remember that *Psylla* does not do the greatest damage, and I would be inclined to consider the treatment of *Psylla* in connection with that of the disease X. At present both do their work in the koonties; it would seem possible to avoid having koonties at all and to plough all the Java crop after the first cutting. In many cases koonties have hardly been worth keeping; and if the ploughing out of koonties were to affect the amount of *Psylla* and also of X, the loss of the second cutting would be worth while.

The only alternative I can see is to sow as much Java as possible in February, cut it as early as possible and to carry out the cutting in the way indicated above.

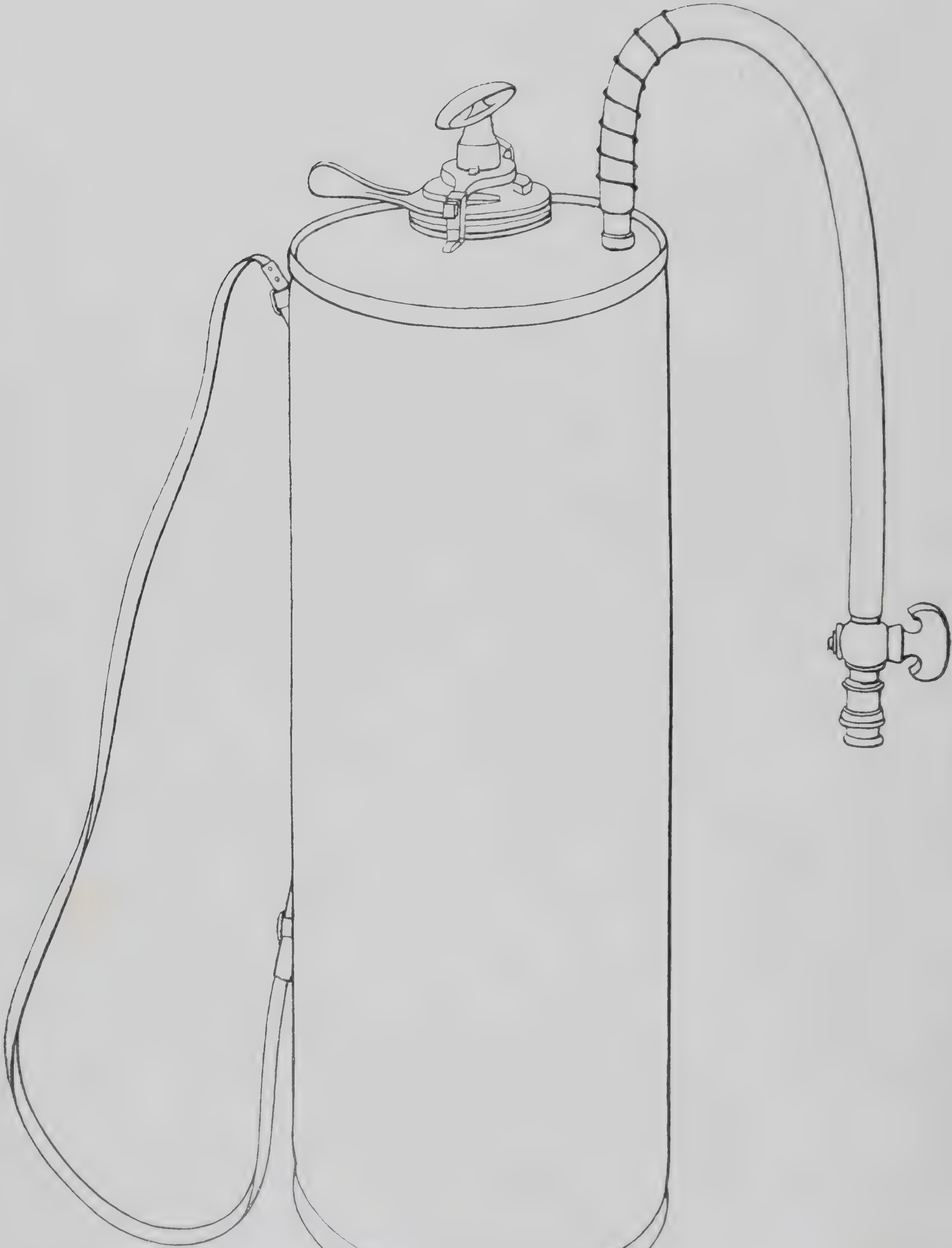
It is impossible to lay down a course of action for Concerns scattered over Behar; what suits Darbhanga does not suit

Champarun; but it would be advisable for Planters to try to secure two things: (1) a break if possible some time in the year when there shall be no Java in the land, this being in the winter if possible, (2) to make it as difficult as possible for the *Psylla* to live in the fields when the plant is cut.

Two alternative systems have been suggested; one is to sow Java in August, get a seed crop in February and a moorhun cutting in June; then plough. The other is to sow only in February, get two cuttings and keep only the best plant for seed. The latter is, where possible, probably the best as it fits in with the Sumatrana plant cultivation and leaves the land free entirely from indigo in the cold weather. It has been suggested that it may be possible to grow healthy indigo by sowing it with other crops, *e.g.*, wheat, linseed or mustard. So far as I have seen, this practice has not affected the amount of either *Psylla* or X except in one case; some of the most healthy individual plants I have seen were in cane; they were volunteer plants, not having been sown, and were scattered through the cane. If one such plant had got *Psylla*, it had it badly, but the greater number escaped, presumably because the *Psylla* never found it. It is, however, impossible to grow indigo in this way.

Direct Remedies.—A number of experiments have been made with remedies and it is unnecessary to go into detail regarding most of them. We have tried a number of methods of directly attacking the insects; shaking the plants vigorously fails to dislodge them; they are not attracted by light; passing a sticky rope or cloth through the crop fails to do more than capture a few winged adults. A mechanical method of cutting off the tips of the plants in July has not yielded any good result. I still believe that good results will follow the cutting of infested tips if this is properly done; but it is essential that this shall be done by hand, not by a machine, that all "kookragia" heads (curly tops) shall be cut, that they shall be placed at once in bags or baskets and either placed in boxes covered with fine wire gauze or removed to a place where they can be spread out in a layer and covered with cloth. Once a day the

PLATE III.



A. J. I. Auto-sprayer ready for use.

cloth is lifted, the parasites that emerge allowed to fly away and the cloth replaced. It is a mistake to cut the tops and either leave them in the field or burn them with the parasites in; what is required is to place them so that the *Psylla* nymphs cannot get to the plant but to let all parasites emerge which they will do within ten days. As I have had no opportunity of giving this method a proper trial I cannot recommend it, but I think it is worth giving a trial on a small isolated block of plant.

In my previous note, I suggested spraying as a method of directly checking *Psylla* on plant kept for seed. This method has been tested and has given good results. We have sprayed koonties at Dholi, Pusa, Begu Sarai, Sadowah, Sonbarsa and Seeraha : in all we have used soap solution and we have found that the compressed air type of sprayer is the simplest for field spraying and the best adapted to the physique of the Behar coolie.

Soap.—We have tested a series of soaps supplied by firms in India, taking into account :—

(*a*) wetting power on curly tops;
(*b*) killing power on *Psylla*;
(*c*) amount of water in the soap;
(*d*) cost.

We have also tested these with insecticides added and, without going into detail, the best solution we have found which will wet indigo, penetrate the curly tops, kill *Psylla* nymphs and adults, is the Oline soap made by the North-West Soap Co., at Rs. 21 per cwt. or as. 3 per lb. This is used at a strength of 1 lb. to $12\frac{1}{2}$ gallons of water.

The Imperial Agricultural Chemist assisted by determining the surface tensions of soap solutions as compared with water and with emulsions of oil and of creosote. The soap solution had a far lower surface tension than water and the addition to it of oil or creosote in emulsion raised the surface tension. As it is important to have a low surface tension, these results confirmed the actual tests of various liquids on the plant.

Soaps differ very much in water content; we found by drying over calcium chloride, the following losses of weight in soap :—

No.	Days dried.	Loss of weight per cent.
1	31	4
2	{ 11 31	{ 44 50
3	16	8·6
4	12	55
5	9	18

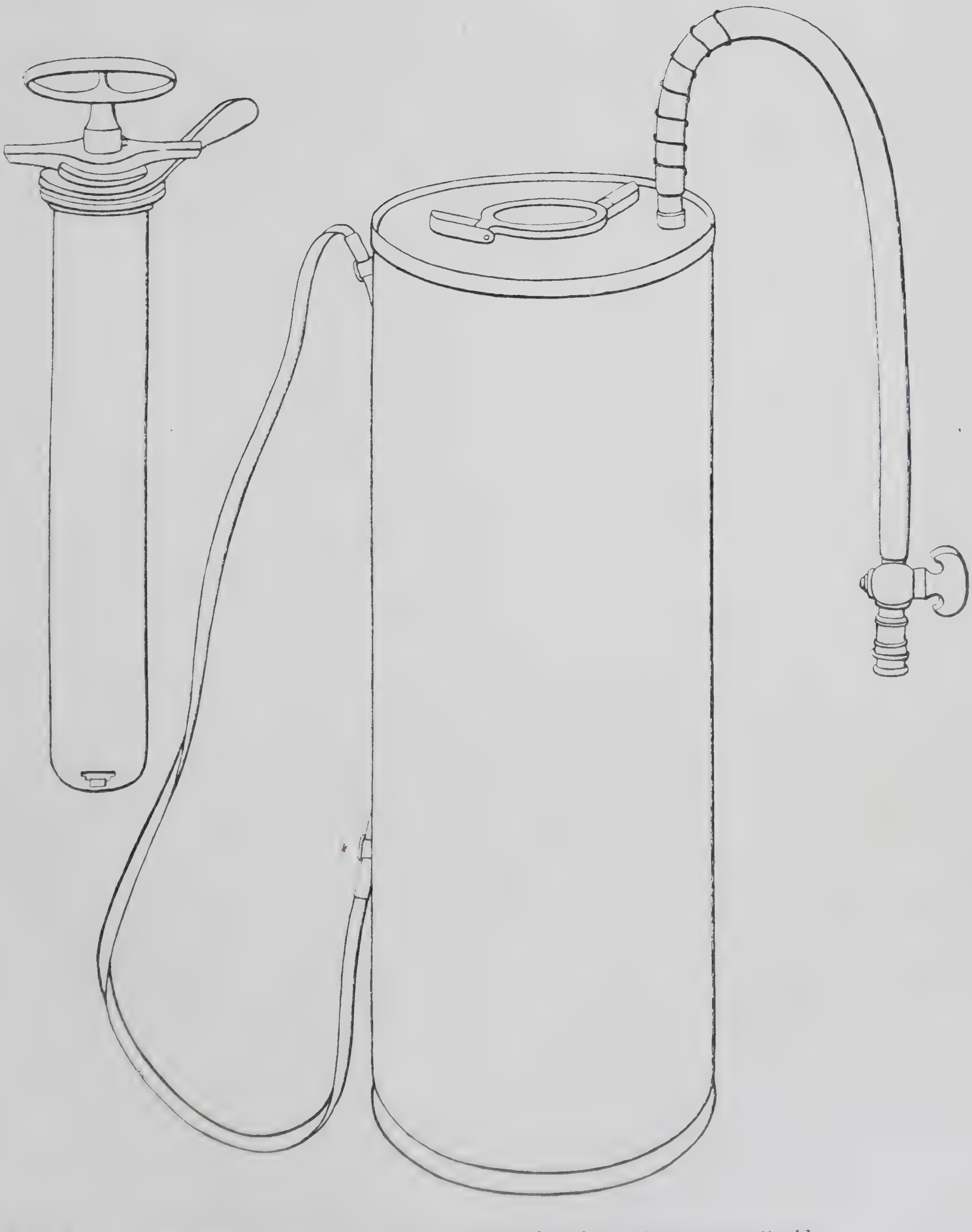
Soap No. 1 costing as. 3 per lb. is cheaper to buy than No. 2 costing as. 2 per lb., as half of the latter was water. We believe we have in Oline bar soap the best available soap for this particular purpose and we have used it exclusively.

Sprayers.—We have tested every kind of sprayer available; we made a cart sprayer doing a strip 15 feet wide automatically; we have used barrel sprayers, knapsack sprayers, bucket sprayers. All can be used, but for spraying koonties with ordinary coolies, we believe that the Auto-sprayer does the best work. Detailed results are given below of the spraying of 110 bighas of indigo.

The Auto-sprayer (Plates III, IV) is a simple cylinder, containing an air-pump; it is first partly filled with the liquid; it is then closed, and air pumped into it till there is a good pressure; the coolie then takes it, walks along the indigo with the nozzle open, the compressed air making a good spray; all the coolie has to do is to hold the machine and direct the spray to the plant. For coolies of low physique this machine is the best; we used the Auto-sprayer costing Rs. 30 in Calcutta (Smith, Stanistreet & Co.), because it was available; other makes using the same principle are made and are probably equally good.

3. *Time to Spray.*—No spray found has been effective in killing the eggs; it is therefore necessary to spray twice, with ten days between the two sprayings. Assuming the first spraying to kill all the nymphs and adults, the eggs hatch and

PLATE IV.



A. J. I. Auto-sprayer with the air-pump removed and ready for charging with liquid.

become nymphs which will be killed as nymphs or adults by the second spraying; if ten days elapse all the eggs that survived the first spraying must have hatched, but none will have been able to become adult and lay eggs. But care must be taken that each block really is sprayed again ten days after the first.

Our spraying was of necessity done in September-October. I believe it will be best to have one spraying in the koonties in July-August, whenever the attack is seen to be commencing and another, if required, in September or October.

Cost of Spraying.—Statements are attached showing the actual cost of spraying areas varying from 4 bighas to 48 bighas. The cost varies from Re. 1 to Rs. 2 per bigha for each spraying depending on the area, the height of the crop, the distance from the factory and the expertness of the men. The work was done in each case by three coolies from Pusa with three Auto-sprayers and with usually six coolies supplied by the factory, of whom three relieved the men working the machines and three brought water, boiled soap solution, etc. The solution was made by dissolving each 3 lb. bar of soap in 3 gallons of water and then diluting to 35 gallons.

Spraying Indigo.

Sadhowah : *First Spraying.*

Area. Bighas.	Area. Kuttas.	Amount of Soap solution.	Coolies.	Cost of labour. Rs.	A.	P.
0	7	35 gals.	... 3 @ 2 as.	0	6	0
			$1\frac{1}{2}$ @ 3 „	0	4	6
2	5	175 „	... 6 @ 2 „	0	12	0
			3 @ 3 „	0	9	0
2	5	175 „	... 6 @ 2 „	0	12	0
			3 @ 3 „	0	9	0
1	8	144 „	... 6 @ 2 „	0	12	0
			3 @ 3 „	0	9	0
6	5	529 gals.	... $31\frac{1}{2}$	4	9	6

	Rs.	A.	P.
Total cost : Labour ...	4	9	6
Soap ...	8	7	0
	13	0	6

Second Spraying.

Area. Bighas.	Kuttas.	Amount of Soap solution.	Coolies.	Cost of labour. Rs.	A.	P.
1	15	175 gals.	6 @ 2 as.	0	12	0
			3 @ 3 ,,	0	9	0
4	5	252 ,,	6 @ 2 ,,	0	12	0
			3 @ 3 ,,	0	9	0
0	5	35 ,,	3 @ 2 ,,	0	6	0
			$1\frac{1}{2}$ @ 3 ,,	0	4	6
6	5	462 gals.	... $22\frac{1}{2}$	3	4	6

		Rs.	A.	P.
Total cost : Labour	...	3	4	6
Soap	...	6	11	0
		9	15	6

SONBARSA.

Area.		Amount of soap solution.	Coolies.	Cost of labour. Rs.	A.	P.
0	15	72 gals.	... $1\frac{1}{2}$ @ 2 as.	0	3	0
			$1\frac{1}{2}$ @ 3 ,,	0	4	6
2	5	180 ,,	... 6 @ 2 ,,	0	12	0
			3 @ 3 ,,	0	9	0
0	15	72 ,,	... $1\frac{1}{2}$ @ 2 ,,	0	3	0
			$1\frac{1}{2}$ @ 3 ,,	0	4	6
3	15	324 ,,	15	2	4	0

		Rs.	A.	P.
Total cost : Labour	...	2	4	0
Soap	...	5	1	0
		7	5	0

BEGU SERAI FACTORY.

Area.	Amount of soap solution.	Coolies.	Cost of labour. Rs. A. P.
3 bighas	91 gals.	... 3 @ 5 as.	0 15 0
		3 @ 1½ ,,	0 4 6
4 ,,	130 ,,	... 3 @ 5 ,,	0 15 0
		4 @ 1½ ,,	0 6 0
4 ,,	130 ,,	...	1 5 0
3 ,,	130 ,,	...	1 5 0
3 ,,	130 ,,	...	1 5 0
3 ,,	156 ,,	...	1 5 0
20 ,,	767 ,,	...	7 12 6

(16⅔ acres.)

		Rs. A. P.
Total cost :	Labour ...	7 12 6
	Soap ...	12 3 2
		19 15 8

Second Time :—

			Rs. A. P.
20 bighas	... 1,015 gallons	Labour	7 12 6

		Rs. A. P.
Total cost :	Labour ...	7 12 6
	Soap ...	16 5 0
		24 1 6

First Time :—

			Rs. A. P.
48 bighas	... 3,276 gallons	Labour	24 2 0

		Rs. A. P.
Total cost :	Labour ...	24 2 0
	Soap ...	51 3 0
		75 5 0

SEERAHA.

Area.	Amount of soap solution.	Coolies.	Cost of labour. Rs. A. P.
5¾ bighas	... 55 lbs. soap :	Labour	5 7 0

		Rs. A. P.
Total cost :	Labour ...	5 7 0
	Soap ...	10 5 0
		15 12 0

Effect of Spraying.—The opinions of the managers of three Concerns are as follows :—

Begu Serai.

"Your man is returning as he has finished the first spraying. I consider it has been most successful. About three-quarters of the plant seems to have recovered. The curly tops are opening out and new leaves are forming."

... ...

Sadowah Factory,
Sewan, Sarun.

... .

"The koonties (Java) kept for seed look A 1 now after being treated with the soap solution which has been done twice."

... ...

Seeraha,
Champarun.

... ...

"The first plot I sprayed here does not seem to have benefited much. This was only a very small plot from which I cut moorhan and kept *all* the koonties. It was badly gone with *Psylla* before the spraying was started. This bit is only a cuttah or two. The rest about 5 bighas in which moorhan was cut, and koonties thinned out, leaving plants about a yard apart or less, has made a very marked improvement after spraying. At first nearly all the plants had curly tops, but now this has disappeared to a great extent and the plant is throwing out new shoots and looking healthy. Some of the plants are still curly ; I suppose there is still *Psylla* on them, and I think that another spraying would put these right. I am very pleased with the result and if the second spraying puts the whole field right as I think it will, and the disease does not at once return, then I expect the plant to give seed, of which at first I had very small hopes.

Seeraha P. O.,
Champarun.

... ...

"I think the plant has benefited a lot. I had better looking stuff than the bit I sprayed, but scattered over the *zilla*, so it was more convenient to do the bit near at hand and in one field. Now I have had to dig out nearly all the *zilla* plant which was at first best, as hopeless, the sprayed stuff being about all I have worth keeping. I wish I had got at the plant on the first appearance of disease as it got a set back before I started spraying it, but I think it will seed now."

... ...

Plant sprayed here (Pusa) has benefited very markedly; the tops have grown through with clean foliage, the curling has ceased, the *Psylla* has disappeared almost entirely and the whole plant becomes green. At the same time this has not been followed by a recrudescence of the disease as in the main the natural enemies of the *Psylla* are not affected by the spraying.

A very remarkable improvement was effected at Sirsiah by spraying, but as the value of the plant there was out of all proportion to the cost of spraying, we sprayed steadily every ten days till satisfied that *Psylla* really was wiped out. Had we been able to commence this treatment earlier, the Sirsiah plant would have suffered much less. Neither at Pusa nor at Sirsiah has spraying affected the incidence of X; it has rendered healthy all plant infested with *Psylla* which was free from other diseases and in this way has made a marked improvement.

Spraying has been recommended for plant kept for seed because of the value of seed plant; it is impossible to spray all koontie plant at present, but it is not difficult to spray, and knowing what the cost is, it is possible, for each Concern to see

whether spraying is worth while. For spraying large areas, a mechanical bullock-drawn sprayer, doing 15 to 20 bighas per day, would cost about Rs. 300. This would require much less labour than 10 auto-sprayers doing the same area and costing as much ; but it would require very good arrangements for supply of soap solution.

THE IMPROVEMENT OF INDIAN WHEAT.

BY

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[A Paper read at the Punjab Agricultural Conference, Lyallpur, November 4th, 1912.]

THE importance of the wheat crop to India both as food for the people and also as an article of export is well known. The average annual outturn is over 8,000,000 tons a year and of this about 75 per cent. is produced in Northern India. Any improvement in the production of this crop, either as regards yield or quality, would mean a large annual addition to the wealth of the country.

On account of the important position held by this crop in India, the subject of wheat improvement was one of the earliest taken up by the Board of Agriculture and this question was fully discussed at the second meeting of the Board in 1906. Six years have now passed and very important results on a large scale have been obtained in many parts of India such as Behar, the United Provinces and the black cotton soils of Central India. Briefly summed up, it may be said that in tracts in which the normal outturn is 8 to 10 maunds of poor wheat the yield has been raised to 25 to 30 maunds, and the type of wheat grown has been classed in England as among the best on the London market. The methods

by which these improvements have been effected have been found to apply not only to *barani* conditions but also to canal-irrigated tracts. An account of the work already done will, therefore, be of interest to the Punjab, the Province which produces about 35 per cent. of the total wheat crop of the Indian Empire.

This work has also an important bearing on the export trade in Indian wheat, for it is clear that any large increase in production will at once swell the volume of wheat shipped from Karachi. One of the primary requirements of the export buyer is a well-grown even sample. Such samples fetch higher prices in the world's markets than badly grown wheat. To obtain such samples good cultivation is essential and any improvements in the methods of production, which will lead to this result, form an important factor in the development of the export trade.

The main lines of improvement are two in number :—

1. *Agricultural improvements* by which the yield has been greatly increased and the appearance of the wheat to some extent improved. In the alluvium of the Indo-Gangetic plain these agricultural improvements consist in the union of hot weather cultivation and dry-farming methods ; combined, where necessary, with green-manuring.

2. *Improvements in the kinds of wheat grown* by which not only the yield and general agricultural fitness of the wheats have been increased but also the quality of the grain.

We propose to deal in the first place with the agricultural aspect of the question.

I.—Agricultural Improvements.

One of the most striking features of the wheat production of India at the present time is the comparatively low outturn obtained by the people. The question arises, "Can this outturn be increased with the means at the disposal of a well-to-do cultivator or zemindar ?" The answer is, "Most emphatically yes." The methods by which crops, at least twice those now produced, can be grown in the alluvium of the Indo-Gangetic plain were first worked

out at Pusa during the years 1906 to 1910 and are now being taken up on a large scale in Behar and the United Provinces. These methods consist in the following :—

1. Exposing the soil to the sun and air *as soon as possible* after the *rabi* crops are harvested. This sweetens the land, tends to kill weeds and also leaves the soil in a proper condition to absorb the whole of the early monsoon rainfall. This exposure of the land should be done as soon as the *rabi* crops are harvested and if the showers, which often fall at this time, are utilised, a good deal can be done to break up, by means of spring tine harrows, the sun-baked and hardened stubbles. The easiest method in canal-irrigated tracts is to water the stubbles first of all and then to cultivate the land thoroughly, but the extent to which this can be done is limited by the water-supply and the cattle power available. The great benefits obtained by hot weather cultivation are recognised by the people of the Punjab and are referred to in *Punjab Proverbs.* These benefits, however, are not sufficiently appreciated and realised in practice.

2. Water conservation and the proper application of irrigation water. To obtain a really good sample, the water-supply of the crop must be properly regulated. This means in *barani* tracts that all possible methods of conserving the available moisture must be adopted. The chief means by which water can be conserved are by clean cultivation and moisture conservation during the monsoon period, by which weeds are destroyed and as much rainfall as possible absorbed and retained up to sowing time, and by harrowing the land after sowing. By clean cultivation is meant the destruction of weeds by ploughing and harrowing, while the importance of moisture conservation in India is sufficiently evident. This conservation of moisture consists in maintaining a dry surface mulch by means of the harrow, which prevents the loss of water by evaporation during the long breaks in the monsoon. By harrowing the land after sowing, so as to break up surface crusts, a dry surface mulch is formed, which retains the moisture. Lever harrows are very useful in this respect, and have been used in Behar with great

success. In canal-irrigated tracts the wheat crop would be benefited by the use of these harrows after the first irrigation. On the other hand, over-watering must be avoided. In canal-irrigated areas there is a tendency to apply too much water to wheat. This results both in diminished yield and also in loss of quality. The ryot often forgets that wheat is a crop which does not need much water.

3. Keeping up the supply of organic matter in the soil when necessary by occasional green-manuring with *san*. This is done during the monsoon period immediately before the wheat crop. In those tracts which grow *arhar* or *rahar* (*Cajanus indicus*) the fall of the leaves and flowers helps to keep up the supply of organic matter. The purpose of this organic matter in the soil is to increase the fertility, to improve the tilth and the water-holding capacity of the soil. In wheat growing this green manuring is particularly necessary on the lighter lands.

These improved agricultural methods can be summed up as the union of hot weather cultivation with dry-farming methods, combined with occasional green manuring to keep up the store of organic matter.

The effect of this method of cultivation on the wheat crop is extraordinary. A fine crop is the result and the yield is increased at least 100 per cent. Further, the appearance of the wheat sample is improved and such wheats are better filled and *take the eye* more than those grown in the ordinary way. The result is more wheat and better wheat; and these improved methods, wherever they have been properly tried in the Indo-Gangetic alluvium, have always given the same result. They apply both to *barani* conditions and also to canal and well irrigated tracts and to all classes of wheat. At Pusa crops of 25 to 30 maunds are obtained as a matter of course. On many indigo estates, in Behar, the Pusa results have been repeated and even exceeded. In both Behar and the United Provinces cultivators and zemindars have obtained similar results. At Cawnpore, similar crops have been obtained by Mr. H. Martin Leake for several years on a large scale—25 to 30 maunds of

wheat to the acre have been grown with half the quantity of canal irrigation ordinarily used for this crop. At Gurdaspur in the Punjab, similar results were obtained for the first time in the *rabi* harvest of 1912.

II.—Introduction of Improved Wheats.

The second line of advance in increasing the wheat production of India is in improving the wheat plant itself, that is, in the creation of better kinds of wheat by selection and hybridisation. The essential points in this are :—

1. Increase in yielding power.

2. Improvements in general agricultural fitness including rust resistance, standing power and hardiness.

3. Improvement in the quality of the grain.

That any improved wheat must yield well and also possess general agricultural fitness for growth in any particular tract is obvious, and needs no particular emphasis. A cultivator will never be satisfied with a wheat unless it yields well and can be grown to perfection. The question of quality of grain, however, requires some explanation. In considering grain quality it must be borne in mind that about 90 per cent. of the wheat grown in India is eaten by the people, and that only the balance finds its way into the export trade. Any improvement in quality, to be of importance, must satisfy both classes of consumers—the people of India on the one hand and the Home millers on the other. It is fortunate that the class of wheat most liked by the people for food is that which is worth the most money on the home markets. This is a most important point and one which cannot be emphasised too strongly. On many occasions the Pusa improved wheats along with ordinary samples have been shown to cultivators, and they invariably prefer for their own food the kinds which have done best in the milling and baking trials in England. A large number of landholders and educated Indians have eaten these new wheats, and are loud in their praises of the superiority of these types over those which can be purchased

in the Indian market. There is therefore no antagonism between the demands of the people and those of the home markets. Both prefer the same general grade of wheat.

The chief points concerned in the quality of wheat are as follows :—

1. The sample should be well grown and the grains should be even in colour and uniform in consistency like the sample of Pusa wheats exhibited at this Conference. The colour should be white or red, not a mixture of the two. The wheat should be free from dirt and other seeds, such as barley or gram.

2. The consistency should be glassy or flinty rather than soft. The wheat should mill well and should absorb a large amount of water in the milling process. Most of the Pusa wheats take up about 10 per cent. of water in the milling process and are ground in the mill with the minimum amount of trouble. Millers naturally lay great stress on these points.

3. The skin should be thin, so that a large percentage of flour is obtained. Fortunately this applies to most Indian wheats, but this point should not be forgotten in the work of producing new kinds.

4. The percentage of nitrogen should be high and the flour should be greyish white in colour. It should be strong, that is, capable of yielding large well piled loaves like those of Manitoba No. 2 and Pusa 4 illustrated in Pusa Bulletin No. 22. Greyish white flour and toughness of dough are points appreciated also by the Indian consumer, and the superior food value of such wheats is well recognised in India.

5. Other things being equal, the wheat should be a white wheat rather than a red wheat as white wheats give, as a rule, a whiter flour than red wheats. In the Punjab a higher price is often paid for white wheats than for red, so that an effort should be made to conform with the custom of the trade and to produce improved white wheats. This has always been done at Pusa and the new wheats now being grown in Behar, the Central Provinces and the United Provinces are without exception white wheats. There is, however, no objection to high quality red wheats

in the home markets. The best wheats on the English market, namely, Manitobans, are red wheats. Further, red wheats are considered to be hardier than white wheats.

The Pusa wheats exhibited to-day at this Conference illustrate the various points of quality which should be aimed at and a comparison between these new wheats and those which are now exported from Karachi will show what an enormous amount of work remains to be done in improving the quality of the wheats now shipped from the Indus Valley.

In deciding the many and intricate questions of quality which have arisen in improving the wheats of this country, India has been fortunate in obtaining the active interest and co-operation of the highest authority in the empire on questions relating to the milling and baking of wheat. I refer to Mr. Humphries, a former President of the Incorporated Association of British and Irish Millers, who, during his period of office, was largely instrumental in bringing about the present form of contract by which the adulteration of Indian wheats exported to England was reduced to a minimum. All the new Pusa wheats have been milled by Mr. Humphries and then made into bread. His opinion on these improved Indian wheats has been endorsed by the Council of the National Association of British and Irish Millers and by the milling press in Great Britain. The Pusa wheats have been examined by the Liverpool and Calcutta Millers and also by the chief wheat exporting firms of Bombay and Karachi, and they all agree with Mr. Humphries. The best technical and trade opinions in the Empire have thus been obtained on the question of quality and on the class of wheats which will find most favour at Home. This testimony has been singularly unanimous, and Mr. Humphries' opinions have been universally accepted.

Up to this point the two lines of progress in improving the wheat production of the Indo-Gangetic plain have been kept separate. These two lines of progress are :—

1. *Agricultural improvements* by which the yield of wheat can be increased.

2. *Improvements in the kinds of wheat grown.*

There is, however, an intimate connection between these two lines of progress which must now be indicated. To produce the greatest yield the crop must be well grown and the sort of wheat cultivated must be one with high yielding power. To get the highest price the wheat must also be of good quality. To obtain the best outturn from an improved wheat it must be properly grown, just in the same way as a good horse or a good pair of plough cattle must be properly fed if they are to do their work well. To extract from the soil the largest possible profit we must use not only improved methods of agriculture but also grow better wheats. It is only in this way that high yield and high quality can be combined and the cultivator can be shown how to get the greatest monetary return for his labour.

PLATE V.

FIG. 1.—UNDRAINED.

7th October.

A. J. I.

FIG. 2.—DRAINED

EFFECT OF DRAINAGE ON RICE SOILS.

BY

C. M. HUTCHINSON, B.A.,

Imperial Agricultural Bacteriologist, Pusa.

A SET of pot cultures of rice plants was undertaken at Pusa in connection with an attempt to discover some of the soil conditions under which the Ufra disease of rice, at present under investigation, is likely to occur. The results obtained appear to be of sufficient interest to warrant their publication separately as indicating the effect of varying soil treatment upon the growth of this crop.

Seedling plants of the same age and variety were locally obtained, and planted out in twelve glazed earthenware pots, 10 inches in diameter and 12 inches deep ; so far as possible the same number of plants was used in each pot.

Work in Italy by Brizzi on an apparently similar disease known there as "brusone" had resulted in establishing an apparent connection between lack of aeration of the water in which the plants were growing, and the incidence of the disease. In order to test any possible similar connection in the case of "Ufra," the twelve pots were divided into two series ; in those numbered I to VI drainage was prevented by plugging the tubulure at the base of the pot, whilst in VII to XII this was left open, the intention being to renew the water-supply of the latter series from the top constantly, and so convey air through the soil. After two days, however, it was found that, owing to the close texture of the soil used (a local rice soil), no drainage was taking place in the second series, and a third series, numbered I′ to VI′,

was started, in which a layer of cinders 2 inches thick was placed at the bottom of each pot. With this arrangement comparatively rapid drainage took place; in each pot an average depth of 3 inches of water was maintained above the soil throughout the experiment; in the drained pots it was found necessary to renew the water during the first ten days at intervals of 48 hours, about 2 inches of water having apparently drained through the soil in that time; during the second ten days this rate of flow was gradually reduced, the same amount of water passing, towards the end of this period, in about twice the time. The pots were not under cover, so that rain prevented any exact measurement of the amount of water actually supplied.

Further differences of treatment consisted in a preliminary air-drying of some of the soil and the addition of oilcake (mustard at the rate of 15 mds. per acre = 60 lbs. Nitrogen) to certain pots. Thus every alternate pot in all three series contained soil which had been airdried before filling in. Cake was added to Nos. I, II, VII, VIII and I′, II′.

Two additional pots, XIII and XIV, were filled with soil from Noakhali, taken from fields in which the "Ufra" disease had been so bad the previous season as to render the crop worthless. To the soil of one of these, No. XIII, lime, oilcake and green manure (*Crotalaria juncea*) were added; No. XIV had no treatment. The transplanting into pots was carried out on 5th September 1912, and photographs were taken on 7th October, 30th October, and 26th November.

The first observed difference was in the pots to which cake had been added, Nos. I, II, VII, VIII, I′, II′ and XIII. After 32 days' growth after transplanting, all the plants in these pots had turned brown and appeared withered and moribund; this condition is shewn in Plate V.

This effect appeared to be due to a direct toxic action of the products of decomposition of the cake; laboratory experiments carried out at the same time shewed that no nitrification was going on in the saturated undrained soil, but that certain anærobes were producing foul smelling decomposition products

PLATE VI.

FIG. 1.—UNDRAINED.
30th October.

A. J. I.

FIG. 2.—DRAINED.

PLATE VII.

FIG. 1.—UNDRAINED.
26th November.

FIG. 2.—DRAINED.

such as indol, and gases including nitrogen, marsh gas, and carbon dioxide. These gases produced cavities in the soil, similar to those formed in solid sugar media, such as glucose gelatine, by gas producing bacteria; and as the gases gradually escaped through the soil and their formation ceased, these cavities collapsed, and in the case of the well-drained soils the toxic products were carried away by the percolating water. That this was actually the case may be inferred from the comparatively rapid recovery of the plants in pots I′ & II′ which took on a healthy green colour many days before those in I, II, VII and VIII, and eventually made a good growth.

This form of decomposition of organic matter is common in swamp conditions, and the rice plant is no doubt partially immune to toxic products of such anærobic action, although other plants not naturally immune are rapidly killed off by accidental swamping, although they will flourish in running water. When, however, the accumulation of toxic bodies becomes unduly great, as in the pots Nos. I, II, VII and VIII, the rice plant suffers correspondingly, whilst in Nos. I & II the percolating water prevented the accumulation of toxins to this extent.

Plate VII taken on 26th November, 11 weeks after transplanting into the pots, illustrates the final effect upon the crop. It will be seen that the manured plants in the undrained series, although they attained an apparently healthy green condition after recovering from the first ill-effects of the cake, are stunted as compared with those in the drained series, and actually formed no grain at all, being still green and immature. At the same time Nos. I′ & II′ in the drained series, to which cake was added, although vigorous and healthy, formed but little grain, the ears not having matured properly and the grain being light and not well filled.

One of the most marked differences produced by the addition of oilcake was in the tillering of the plants, which was greatly increased by the supply of nitrogen in this form. In the original transplanting the same number of plants, as nearly as possible, was put in each pot; in the table of results the number of stalks harvested shews the great variation due to tillering.

One of the most interesting results of this experiment is afforded by the growth of the rice in the two pots XIII & XIV filled with "Ufra" soil. No. XIII which received lime, cake and green manure, suffered at first (7th October) from intoxication, but eventually recovered (30th October) and made a good growth. It was found, however, on 26th November, when the last photo was taken, that No. XIV which had had no treatment of any sort, not only produced more grain than No. XIII, but gave the best return of any pot in all the series. This is good evidence of the fact that rice soils vary profoundly amongst themselves without showing very much difference either by chemical or mechanical analysis. Unfortunately the sample of this soil obtained was not large enough to allow of comparative treatment under drained and undrained conditions.

An interesting difference is noticeable in the root development of the plants in the two series, and is shewn in the photograph (Plate IX). Only one plant from each series is shewn, as the difference in root development illustrated was absolutely characteristic of every pot.

In the undrained pots the development below soil level leaves the original long stem of the transplanted seedling with a bunch of roots at its lower extremity and long adventitious roots proceeding from the two nodes above it; in the drained pots, however, the lower part of the stem has rotted away, leaving the upper half only, with a much more fully developed bunch of roots from the remaining extremity, and practically no adventitious roots from the upper node. This, I think, may be said to be exactly contrary to the expectation of a deeper root system in a better drained soil. The explanation suggested is that the plants were obtaining food of two different kinds depending upon two different sets of conditions. In the undrained soils anærobic conditions prevailed, and the plants were dependent on food produced by anærobic organisms; probably nitrogen as ammonia would be the predominant factor in this supply; consequently most food would be available where the anærobic conditions were most pronounced, *i.e.*, at the bottom of the pot. In the drained soils different bacterial conditions would obtain

PLATE VIII.

Fig. 1.—7th October.

Fig. 2.—30th October.

"Ufra" Soil.

A. J. I.

Fig. 3.—26th November.

PLATE IX.

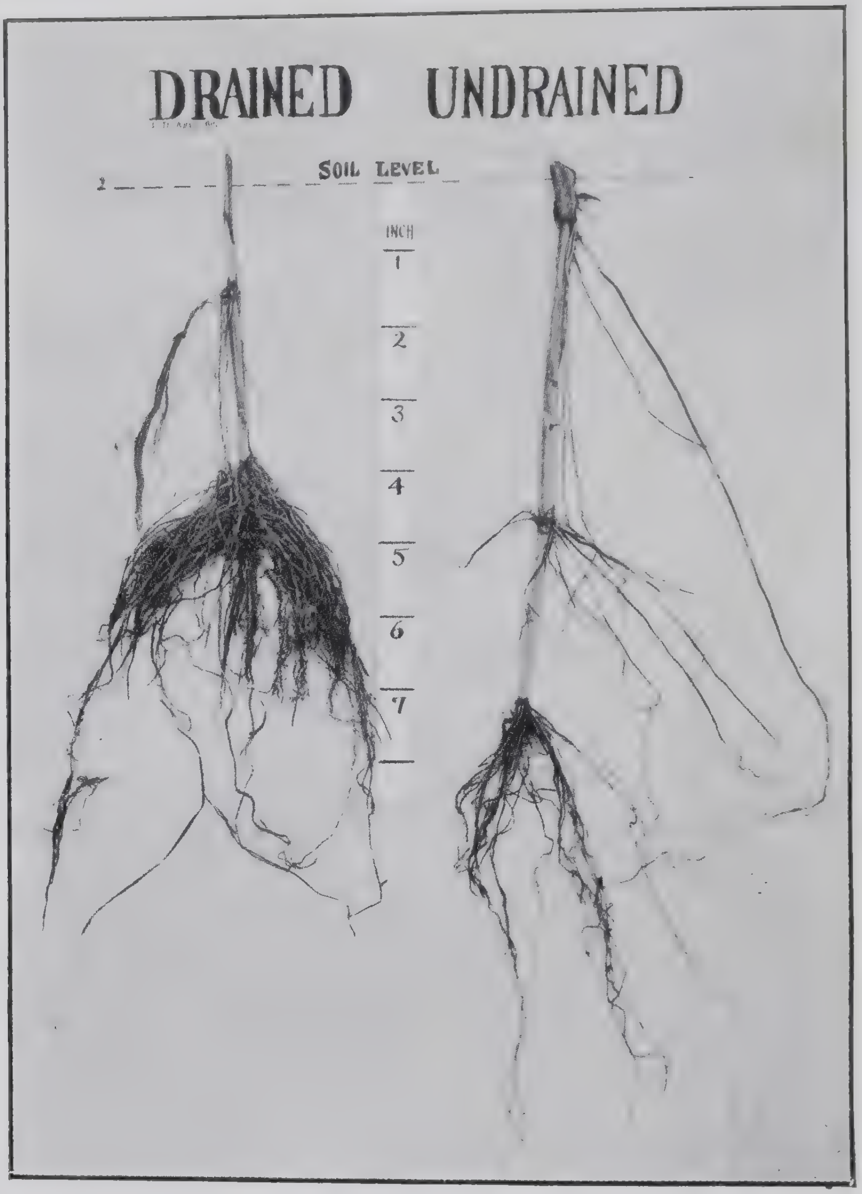
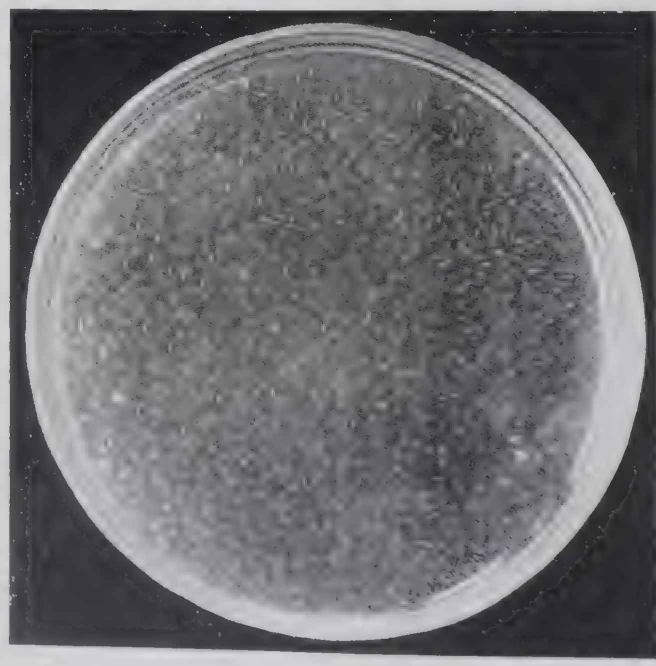


FIG. 1.



A. J. I.

FIG. 2.—No. IV, UNDRAINED.

FIG. 3.—No. IV, DRAINED.

owing to the comparative aeration of the percolating water ; it is quite possible that the nitrogen supply in these pots was mainly in the form of nitrate as, owing to the constant motion of the water, even in its saturated condition nitrification might take place and, although no accumulation of nitrate could occur, still a constant supply might be available for the plant, and, as this would be obtainable where aeration was most intense, a corresponding root development would take place near the surface.

A further difference was observed ; in every case in the undrained series a marked blackening of the root tips occurred, about 20% of all the rootlets being affected. No such blackening was found in the roots in the drained pots. No fungal hyphae were to be found in the blackened roots ; bacteria were present, but time has not allowed of any examination of their characters.

Biological analysis of the soils after harvesting shewed the presence of a soluble toxin in the water extract of the soils in the undrained series. This was demonstrated by introducing a pure culture of B. Prodigiosus into the extracts from the various pots and, after incubating for 24 hours, making agar plates ; the number of colonies on each plate would be affected by the relative amount of soluble toxin contained in the water extract, and would tend to be in inverse proportion thereto. The two plates photographed (Plate IX) were made from water extracts, from pots Nos. IV & IV′, which were typical of the two series ; they afford a clear indication of the presence of toxins even after a considerable period of time (18 days) from the drying up of the soil and harvesting the crop.

Experiments in the field are now being arranged at Pusa to determine the effect of drainage and aeration of the soil upon the growth and maturity period of the rice crop. They will be carried out in conjunction with further experiments on the use of certain salts such as "Khari nimak."

The following table gives the methods of treatment and the weights of crop and grain resulting. Nos. I, II, VII and VIII were still green at the time of harvesting the remainder, and were not cut.

Rice Pot cultures.

Number.		Treatment.	Condition.	Weight in Grams of: Crop.		Grain and chaff.		Grain.		Number of stems harvested.	Ratio. Grain/Stem.
I ...	Airdried.	+ Cake	Undrained.	...	...	...	...	...	...	...	...
III ...	Airdried.		Undrained.	78	...	20	...	19·5	...	22	19·5/22
V ...	Airdried.		Undrained.	108	186	27	47	26·0	45·5	22	26·0/22
VII ...	Airdried.	+ Cake	Undrained.	...	...	...	...	...	...	...	...
IX ...	Airdried.		Undrained.	132	...	31·5	...	30·5	...	28	30·5/28
XI ..	Airdried.		Undrained.	93	411	24·5	...	23·5	...	27	23·5/27
II ...	Undried.	+ Cake	Undrained.	...	...	...	...	...	...	...	...
IV ..	Undried.		Undrained.	99	...	25·5	...	24·5	46·0	24	24·5/24
VI ...	Undried.		Undrained.	96	195	22·5	48·0	21·5		26	21·5/26
VIII ...	Undried.	+ Cake	Undrained.	...	...	...	...	...	...	...	...
X ...	Undried.		Undrained.	103	...	27·0	...	25·5	...	20	25·5/20
XII ...	Undried.		Undrained.	103	401	23·0	...	21·5	...	24	21·5/24
I′ ...	Airdried.	+ Cake	Drained.	366	...	42	...	33	..	55	33/55
III′ ...	Airdried.		Drained.	115	264	28·0	62·0	26·5	...	28	26·5/28
V′ ...	Airdried.		Drained.	149	630	34·0		32·5	59·0	27	32·5/27
II′ ...	Undried.	+ Cake	Drained.	325	...	35·5	...	28·5	...	52	28·5/52
IV′ ...	Undried.		Drained.	122	259	35·0	65·5	33·5	63·0	30	33·5/30
VI′ ..	Undried.		Drained.	137	584	30·5		29·5		29	29·5/29
XIII ...	...	"Ufra" soil + cake & lime + green manure.	...	303	...	38	...	28·5	...	59	28·5/59
XIV ...	...	"Ufra" soil untreated.	...	256	...	56	...	54·5	...	71	54·5/71

PLATE X.

A. J. I.

Young Stock on a Ranch, Texas, from English Bulls.

DRY FARMING.

BY

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Deputy Director of Agriculture, Sind.

Of late years much has been heard about Dry Farming, and, largely owing to subsidised or interested publications from the United States of America, it has received much mention in the press. The name is somewhat misleading, it simply means farming conducted in semi-arid regions without irrigation. In arid and semi-arid countries there are tracts of land which were formerly considered only of value for stock rearing, which gave a scanty yield of grass, requiring immense tracts to pasture the stock. It is obvious if speculators could acquire these lands cheaply, break them up into small farms and sell to colonists, then much money could be made. Much of the "boosting" of dry farming can be traced to the efforts of those speculators to attract settlers to make homesteads in the Great Plains lying to the East of the Rockies in the centre of the U. S. A.

In connection with dry farming, statements have been made that so-and-so's 'system' is the only method of any use, and that various systems are applicable to all conditions of semi-arid countries. Also that any country, with a rainfall of between 10 and 20 inches, is suitable for dry farming. The United States of America Department of Agriculture have always maintained a cautious attitude in regard to dry farming. In various stations they are working out arid cultivation problems systematically.

Many people have suggested that the Indian Agricultural Department should conduct extensive dry farming experiments

especially in the districts which are subject to famine conditions. A visit was made by the writer to the Southern end of the Great Plain of the U. S. A. in 1911 to see dry farming carried out under conditions somewhat similar to those pertaining to India.

To compare different localities in this connection it is necessary to look at the following points :—

I. *Rainfall*, annual amount of precipitation, distribution during the year, percentage run off from land.

II. *Temperature*, annual range and mean temperature, duration of frost if any, and dormant season, amount of evaporation, existence of hot winds.

III. *Soil*, physical character whether retentive of moisture, natural features such as hollows between hills forming natural catchment basins.

In North Texas and part of New Mexico the natural conditions are more similar to those found in India than other parts of the Great Plains. This forms the Llano Estacado or Great Staked Plain. It extends to 50,000 square miles and stands 5,000 feet above sea-level. The soil is generally a brownish loam and is covered with buffalo grass (*Bouteloua digostachya*), this is hardly visible during the dry spells but springs up after rains and the whole country looks green. The surface varies from level to small rolling hills with flat tops not unlike parts of the Deccan. The temperature varies from a maximum of 110° F. to 5° F.

The various "systems" in vogue are all earnestly advocated by their originators as suitable for all conditions. Some systems advocate deep ploughing, others shallow ploughing and summer fallowing with wide spacing and thin seeding of the crop, others pressing by the sub-soil packer (a roller made up with loose iron discs) and all generally agree that a dust mulch should be kept on the soil as far as possible all the year round. This dust mulch is an inch or two of fine soil on the surface; it breaks the capillary connection with the soil and atmosphere and so minimises evaporation, and it also readily absorbs any rainfall.

PLATE XI.

A. J. I. Dry Farm 'Juari,' Texas, showing thin Seeding in Drills to allow intercultivation.

PLATE XII.

(*a*) JUARI CROP, AMARILLO.

(*b*) SUBSOILING, AMARILLO.

A. J. I.

(*c*) BUFFALO, ONE OF THE FEW SURVIVORS.

The underlying principle is to keep the soil receptive and retentive of moisture and the retention of the dust mulch does this; the soil being carefully cultivated after every fall of rain where possible.

The U. S. A. Agricultural Department recommend no system but believe in modifying their methods according to varying conditions, and farming according to the common rules of good husbandry for humid regions. They are also paying a great deal of attention to selecting drought resisting plants and breeding them up, also to the collection of suitable varieties from foreign arid countries. They have a large staff of plant collectors who travel all over the world on the look-out for promising introductions.

Amarillo is the site of one of the United States of America experimental dry farms. It is quite a new city on the Rock Island Railway. Round about, a large number of farms have been cut out of the old ranches, much to the disgust of the original stockmen. The city is situated in a flat plain. The rainfall in 1911 had been less than 15 inches, and the crops, chiefly jowari, maize and cow peas were looking very poor. In India such crops would probably have received remission of the land tax. The farmers generally elect to put in as large an area of cultivation as they can, and in a year of good rainfall do fairly well. Most of the farmers cannot afford to go in for very elaborate cultivation. Their ploughing is shallow and the crops are drilled wide apart, and between the rows intercultivation is done from time to time. The general opinion among settlers seems to be that summer fallowing does not pay and neither does sub-soiling. One farmer stated that he was pleased when he obtained 15 bushels grain per acre every second year. Land is selling at 20-30$ per acre for 'made farms.' Here and there some especially good results are reported, but they are generally due to special circumstances, such as neighbouring hills forming a catchment basin or seepage water percolation from high land laid on impervious clay.

The crops on the Government Farm at Amarillo were much above those of the neighbouring farmers. About 80 acres are

under cultivation. The rotation generally is jowar followed by 2 small grain crops, generally wheat and oats. Yields up to 30 bushels are obtained. Summer fallowing is not recommended as it is not considered profitable. An occasional sub-soiling about 10″ deep every few years is beneficial.

It is very doubtful, however, if such expensive working of the soil pays; and the land is not safe till the crop is of a fair height, as high winds occur occasionally and blow away the dust mulch, leaving the land dry.

Dalhart is another U. S. A. Agricultural Department dry farm station. It is to the north of Amarillo. It is situated a short distance outside a brand new and bustling little city of that name. The country is more rolling towards the north, with the usual reddish soil, and quite treeless. Most trees will not grow, and the winds affect others badly. Round some farms, however, may be seen catalpas, Russian mulberry and Osage orange, which are all drought resisters and quick growers.

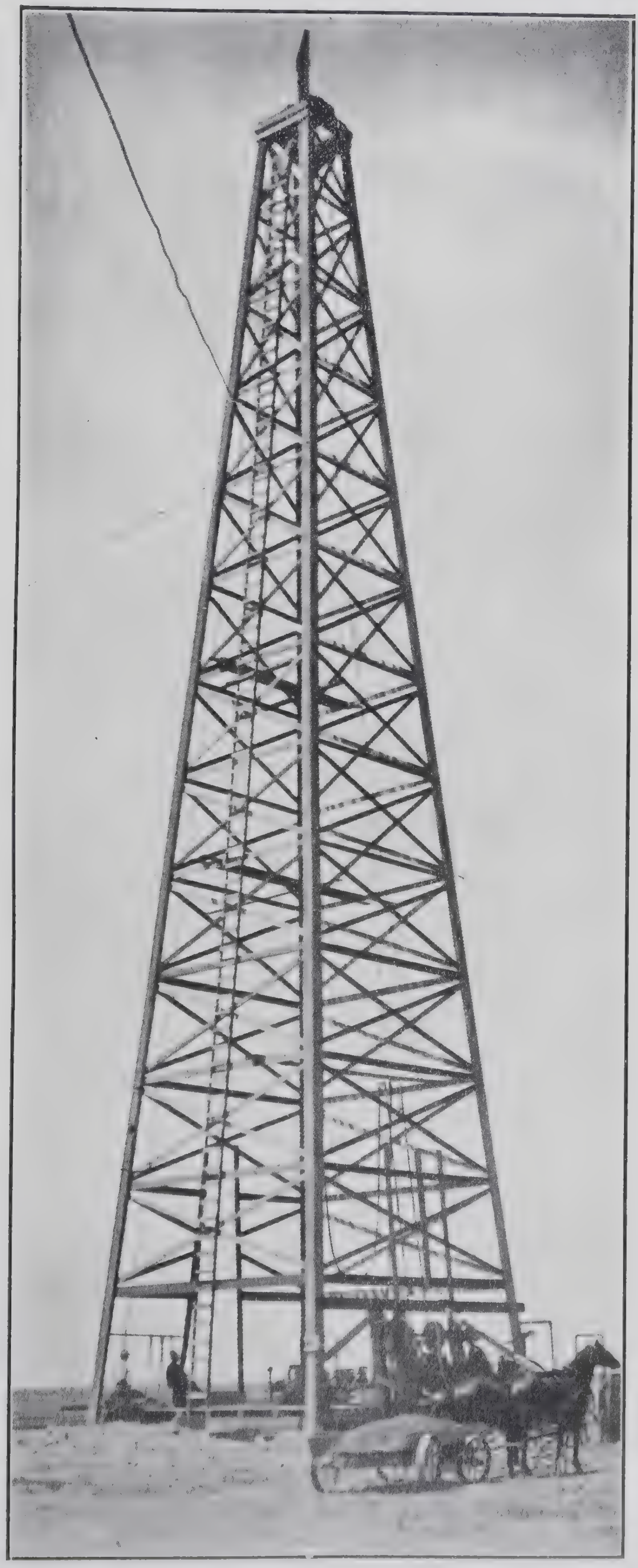
Drinking water is a problem for the towns, and artesian wells are being made in some cases. In the photo opposite of a superstructure of a bore the depth reached was over 800 feet and was being deepened.

Some good stock can be seen on the ranges while passing; they are generally the produce of pure bred bulls. A few buffaloes (bison), can still be seen in a semi-wild state, it is only a few years since they could be seen in the plains in thousands.

When capital is available the plains are very suitable for power cultivation, the large flat unbroken prairie forms an ideal ground for steam and oil engine tackle. The work can be pushed on very quickly, which is a matter of great importance. Generally direct tractors are used. "Gasoline" tractors are coming into fashion. Plate XIV shows a plant being worked and drawing a cultivator, packer and drill behind it. The working crew live in the "caboose" shown in the background while on tour.

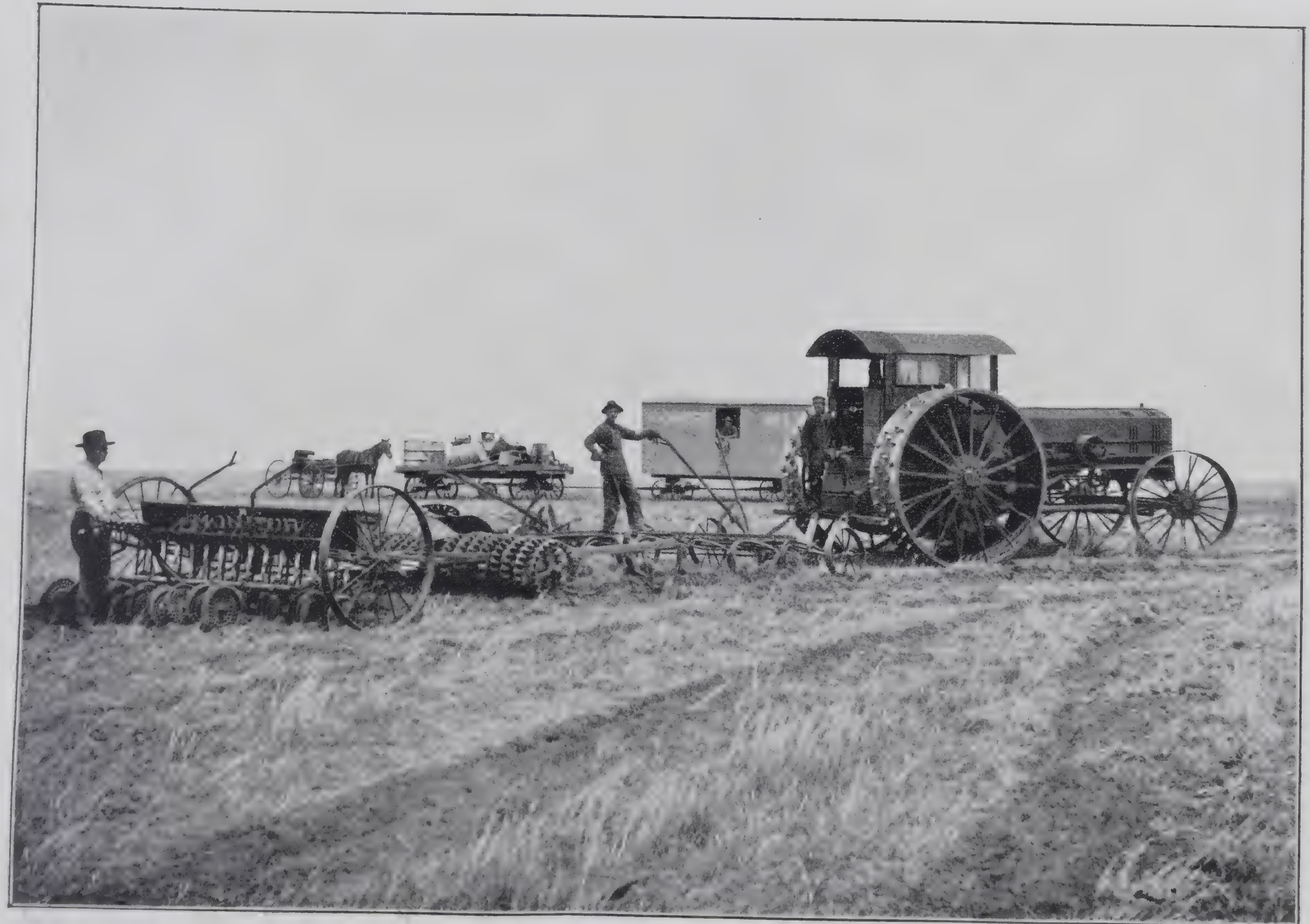
The Dalhart farm, under the charge of Mr. W. D. Griggs, has been running for 4 years and much interest is taken in it by

PLATE XIII.



A. J. I. ARTESIAN BORE, DALHART, TEXAS.

PLATE XIV.



A J. I.

Gasoline Engine and Outfit, Cultivating, Pressing and Seeding.

neighbouring farmers. Like Amarillo the land and buildings are supplied by the township, while the U. S. Agricultural Department supply the staff. The farm crops, owing to a dry season, were below average, but much better than neighbouring crops. This part of the country is very subject to high winds, so the top surface of the land is generally left fairly rough, being finished off with a disc plough. A wind over 50 miles an hour will blow the whole surface from a field if loose and uncovered. It has been recorded that a newly manured field has had the manure completely blown away, and deposited on neighbouring land.

A method recommended by the station is to plough 8″ deep in the Autumn and give 4 workings in the Spring, leaving the surface rough with the disc plough. Then sowing is done, the drills being $3\frac{1}{2}'$ apart and 1′ between plants in the rows. Plate XV shows the difference in size of crops with this method in comparison with only a 3″ ploughing in spring. A common rotation is

Kaffir corn
Milo
Sorghum
Cow pea.

Kaffir corn is jowar with loose ear heads and Milo is jowar with compact heads. 20 bushels per acre is considered a good yield on the farm.

The opinion of the Dalhart farm staff is that where the rainfall is less than 18″ per annum the other circumstances being favourable, the crops will be very doubtful. On the plains there is little snow in winter and frosts are light. Evaporation on the other hand is very high.

Going through Oklahoma, Kansas, towards the East it is interesting to note how as the humid region is approached the crops improve till the typical maize and lucerne country is reached.

Mr. Chilcott, in charge of the dry land investigations, U. S. Department of Agriculture, has laid down the following

conclusions in the current year book of the Department. They are most important, and show the views of the Government based on carefully conducted experiments at many stations, and can be compared with the loose and inaccurate statements often put forth in dry farming publications.

Serious Misconceptions concerning Dry Farming.

I. "That any definite 'system' has been or is likely to be established that will be of general application to any considerable area.

II. That any hard-and-fast rule can be given to govern methods of tillage in time and depth of ploughing.

III. That deep ploughing necessarily increases water holding capacity of soil.

IV. That alternate cropping and summer tillage can be relied on as a safe basis for permanent agriculture or that it will overcome effects of drought.

V. That definite rules can be laid down to operate a dry land farm."

In regard to the application of American practice to India it would seem that the largest field lies in the selection and breeding of drought resisting plants and in the collection of economic plants from foreign arid countries.

More cultivation would in famine districts render the lands more receptive and retentive, but generally the cultivators are unable to do this after a bad year, their cattle are scarce and in bad condition, and are not strong enough to pull heavier and more efficient implements even if they possessed the latter. It is interesting to note in this connection that the practice in the "bosi" lands of Sind follows out American practice very closely. Here the "bosi" land receives a 5″ or 6″ watering in August. On drying it is carefully ploughed several times and gone over with a very heavy roller till a dust mulch is made on the surface. In October wheat, etc., is drilled down into the moist soil and the crop receives no further irrigation.

PLATE XV.

A. J. I. JOWARI PLOTS, CROP ON RIGHT PLOUGHED 8″ DEEP IN AUTUMN.
" " " LEFT " 3″ " SPRING.

THE PROBLEM OF THE IMPROVEMENT OF THE INDIGENOUS COTTONS OF THE UNITED PROVINCES.

BY

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AND

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In Vol. VI, Part I, of this Journal for January 1911, appeared a reprint of an article entitled "The Problem of the Improvement of Cotton in the United Provinces" which was written originally in connection with the Agricultural Conference held during the Allahabad Exhibition and to explain the cotton exhibits at that exhibition. During the two years that have elapsed considerable progress has been made in the experimental and practical work on the indigenous cottons which is being carried out by the United Provinces Department of Agriculture, and the interest which is being taken in this work, render it advisable, in the absence of detailed reports on the subject, to review the present position of this work.

The work falls into two clearly defined sections—the experimental and the economic. It is first necessary to find, or to produce, some type, or types, which will yield a greater return to the cultivator than the present mixture grown by him. It is, then, necessary to develop an organisation, which takes into account the economic aspects of the problem, for the replacement

of the local mixture by these types. We hope to show in this note how far these objects have been realised up to the present moment.

Before, however, it will be possible to indicate this, it is necessary to outline certain fundamental principles, based partly on economic facts and partly on the nature of the cotton plant—which it is necessary to keep prominently before the mind if success is to be attained and an improvement of the cotton crop is to become established.

The outstanding features of the cotton problem of to-day are the proximity of a world's shortage of the raw material and, as the problem more nearly affects Britain and British possessions, the development of the mills in America. In practice this means that America will continue to absorb more and more of her own produce and that by that amount will the supply to Lancashire be diminished. The cry in Lancashire is for more, and still more, cotton. The quality of that raw product is of secondary importance. The world's mills may be divided roughly into two classes—those spinning fine counts* and those coarse counts of 20's and under. The bulk of the Lancashire mills fall into the former group and require as raw material a fairly long staple. This is found in the American cotton, from which country the bulk of the raw material comes, though a number of other cotton-growing countries, especially Egypt, and India also to a certain extent, produce cotton of the required quality. Low counts are spun very largely on the Continent, in India and in China, and recently in Japan. In the face of a world's shortage, or at least a shortage in the Orient, any increase in the supply of raw material is beneficial. There is sufficient latitude in the mills of the two types above indicated to produce an adjustment which is largely automatic. A large increase in the raw material suitable for spinning low counts will lead to a lowering of cost and, automatically, a certain amount of raw material suitable for

* Spinning 40's and upwards, *i.e.*, spinning yarn giving 40 or more hanks to the pound. A hank being 840 yds. of thread, it is clear the higher the count the finer the thread and the longer the staple required to produce the necessary strength.

higher counts will be liberated. We may conclude, then, that the main object is to produce an increase of the supply of raw material *of any quality*, and we are inclined to think that this is the true definition of the cotton problem of the world.

The first and, probably, the most obvious, method of increasing this supply is to increase the acreage. It must not, however, be forgotten that the acreage put under a particular crop in a given area is the resultant of many economic factors which are only partially under control. Thus, of the economic conditions which hold for the United Provinces, the guiding factors are the small size of the holdings and the absence of the capital. The first object of the cultivator is to provide food for himself and family and after that for his domestic animals. Having arranged for the supply of these, he is then in a position to consider what is the most suitable, or most valuable, crop he can grow in the remainder of his tenement subject to such limitations as are imposed by questions of suitability of land, nature of the season, rotation and the like. The cultivator wishes to get the best return he can from the land at his disposal and will, therefore, put down the crop that is likely to pay him best under the conditions which obtain. India as a whole has not yet attained that development in matters agricultural which is brought about by increased facilities in transport and under which the major crops tend to become localised into the areas most suited for their production. The village, and even the family, is still, to a very great extent, a self-supporting unit.

Until such conditions are established, it is impossible to increase the cotton acreage directly in a fully settled country like the United Provinces. The present figure is the balance struck by the existing economic conditions. It may be possible in new tracts, such as the new canal colonies of the Punjab, to introduce, as condition of tenure, the growth of a certain area in cotton,* but no such method can be adopted in these Provinces.

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* *Vide* recommendations of Deputation to Secretary of State for India, 1912.

Increased area here can only be brought about by increasing the value of the produce of a unit area. Thus the problem, especially as it applies to the United Provinces, is still further reduced to finding some method of increasing the value of the produce of a unit area, in other words, of increasing the money return to be derived from an acre of the crop.

Three methods suggest themselves, and they are—

1. To increase the quality of the product. Other things being equal, improved quality of the produce means a potentially more valuable crop ;

2. To increase the quantity or yield. This is the simplest and most direct, and with it is closely linked—

3. To increase the ginning outturn. The raw product, or kapas, gathered in the field consists of the two portions, lint and seed, of which the former is the more valuable. By increasing the ginning outturn, the percentage which this more valuable lint forms of the entire produce is increased and with it the money return from the crop as a whole.

Before we enter on a fuller discussion of these methods, a brief reference to further economic conditions must be made. Practically the entire crop in these Provinces is handled by middlemen in its passage from the cultivator to the consumer and it is with this middleman that the cultivator alone deals and to whom he looks for the immediate return for produce delivered. It is, therefore, the price this middleman is prepared to give, rather than the value of the produce to the consumer, which controls the growth of the crop. It is clearly of advantage for this agent to handle a single article in bulk rather than small quantities of different grades. It is for this reason that it is found so difficult to ensure the true value of the quality of the produce reaching the grower. Left to his own resources the cultivator has often to accept a price for his better produce which is less than that given for the inferior crop commonly grown. Of this we could give instances met with in our actual experience. We are here face to face with an economic force of no mean order which militates largely against dependence on

quality alone to bring about an increased money return per unit acre. Such forces are not readily surmounted and can only be met by an organisation of the buying agencies which will ensure the cultivator obtaining full value for quality. The difficulty is especially marked during the early stages of the introduction of types possessing a better quality of lint—that is, at the critical time when it is most desirable that the cultivator should appreciate the true value of his produce, he is least likely to obtain that value.

For our part, we are inclined to consider that such a radical change of method is likely to be slow. In our attempts to improve the value of a unit area, by an increase of quality we propose to subject all improved types to the critical test of a determination of their value at the current market rate of the local produce ; in other words before such improved types pass from the experimental stage they must have proved themselves to be not inferior in yield, ginning percentage, et cetera, to those locally grown. The test is a severe one and may prove impracticable, but in this way only is it possible to ensure that the cultivator will not suffer.

We have shown that, under present conditions, the quality of the lint is of little value to the cultivator in the absence of special facilities for marketing his produce. There remain two points only which he can fully and directly appreciate, the yield and the ginning outturn, to which may be added to some extent the colour. With the yield he himself is alone concerned. For the second he is largely dependent on the purchaser. The ginning outturn is at the present time the controlling factor in the price paid for the produce, in that the purchaser is prepared to pay in nearly direct proportion to the figure at which the kapas gins. Thus he will pay Rs. 10 as. 10 per maund for kapas ginning out at 39% when he pays Rs. 9 as. 3 per maund* for *desi* kapas ginning out at 33%. In the ginning outturn, therefore, we have at once a most ready and most easily appreciated means of improvement.

* Values which have been obtained during the current season.

Before we leave the economic aspect of the subject, we may refer briefly to one further matter which intimately concerns the practical introduction of such improved types as are obtained. In the crop which covers over $1\frac{1}{4}$ million acres and which produces as much as 400,000 bales per annum a small percentage increase in yield, say 5%, is very perceptible. Owing very largely to the fact that the cotton crop is aggregated in the S. W. corner of the province—with its centre at Muttra—in which district some 30% of the kharif area is sown to cotton—the varying climatic conditions from year to year produce large fluctuations in the yield from the Province as a whole—larger than would be the case were the crop evenly distributed throughout when unfavourable conditions in one locality would be, in most seasons, compensated by favourable conditions in another. A 5% increase, such as we have presupposed, would be lost in the fluctuations which occur from season to season. It would become apparent only when comparative tests are conducted in the same locality and the error due to climatic variations thus eliminated. In practice, however, the relative value of two crops is not judged by such careful comparisons nor even by the returns of any wide area. The total area under the crop is divided into an infinitesimal number of small holdings, each under the ownership of a different cultivator who is very largely guided by his own personal experience. Under such conditions the variations caused by climatic conditions are extreme, and a 5% increase, such as we have presupposed, would become entirely masked. An increase, to be perceptible when judged under such conditions, must, we believe, be at least 20—25%. For this reason it is hard to convince the cultivator of the value of a particular type unless the increased return attains to some such figure as indicated. This argument, in the case of cotton, clearly applies to yield of kapas only. It does not apply to the ginning outturn which, therefore, forms the most salient point for attack in efforts at improvement.

We may now pass to a consideration of those aspects of the problem which are conditioned by the nature and habit of the

cotton plant and its interaction with its surroundings. Foremost among these we place the method of branching. This point has been dealt with in detail by one of us elsewhere.* Here it will suffice to say that on the nature of this branching depends the earliness or lateness of the flowering period and hence of the crop. The length of the vegetative period—that is, the time that elapses between the dates of sowing and of the appearance of the first flowers—will vary, according to the nature of the branching habit, from 55 to over 200 days. Now the climatic conditions under which cotton is grown in the United Provinces impose a very definite limit to the growing period. The cold weather, throughout the cotton tracts, is sufficiently intense not only to check growth but to kill the plant back. The plant must have flowered and fruited before this has well set in. Nor again is it possible to increase the vegetative period indefinitely by early sowing. Plants sown too early and exposed to the hot weather develop a stunted habit with precocious flowers. There is, therefore, also a marked anterior limit to the growing period. These limitations reduce the possible vegetative period to a maximum of 100 days. With types having a vegetative period of this length sowings will have to be made in May or early June, *i.e.*, before the monsoon sets in. Such types, therefore, require to be sown on irrigation and are suitable for irrigated tracts only. From the statistical returns it appears that of the $1\frac{1}{4}$ million acres, only $\frac{1}{4}$ million or some 20 per cent. are irrigated. Nor is the area irrigated equally distributed throughout; there are large tracts in which cotton is sown almost entirely on the rains. For these tracts such types are unsuited. The problem is, therefore, two-fold. An early flowering plant, which will yield a crop, even when sown on late rains, is required in addition to one suitable for growth on irrigation.

One further point on this aspect; it is useless to grow a plant which will fruit before the rains have well ceased. When such is the case the plant becomes exhausted in the production of bolls

* Journal of Genetics, Vol. 1, 3-1911.

which do not open or, if they do so, yield a very inferior and weak lint. There is, therefore, a definite limit, not only to the growing period, but also to the vegetative period. The ideal conditions for a full crop are found when the plant is in full boll and beginning to ripen its fruit shortly after the withdrawal of the monsoon. It is, therefore, as mistaken a practice to sow an early flowered type on irrigation as it is to sow a late flowered type on a late monsoon. The dual nature of the problem is thus very evident, it is not possible to evolve or obtain one type suited to the varying conditions of the Province. Owing, however, to the great fluctuations which occur from year to year in the date of arrival of the monsoon, the time for sowings on the rains is largely beyond control, and in some seasons it is possible to sow in this manner but a short time after the irrigated cotton has been sown. For this reason, and also owing to the considerable power which the plant possesses, of immediate response to external conditions, it is as inadvisable, as, for economic reasons, it is undesirable to plant irrigated and unirrigated areas of a single tract to different classes of cotton. The main cotton tracts are roughly divisible into two classes, for the one in which extended irrigation takes place, a late type, and for the other, characterised by little or no irrigation an early type, is desirable.

A second aspect is based on the observed occurrence of a large amount of cross-fertilisation. The method and extent of this have been dealt with in some detail in a former note.* The amount of cross-fertilisation which takes place during the cotton season in these provinces is there shown to be between 10 per cent. and 20 per cent. This means that 10 to 20 plants per hundred will be developed from seeds fertilized by pollen from a neighbouring plant. The amount is sufficient, when small areas of any type are grown in the proximity of other types, to lead to a complete loss of type in 4 or 5 years. The recognition of the practical bearings of this fact is most essential. They are twofold: (*a*) the necessity of introducing an improved type into, *and throughout* selected areas; (*b*) the desirability of establishing in the

* Memoirs, Dept. of Ariculture in India, Bot. Series, Vol. IV, No. 3.

improved type one or more distinct characters by which it can be differentiated at a glance from the mixture of types it replaces.

How far these varied conditions have been met may now be dealt with. They may be best explained under two heads—improvement by direct selection and improvement by breeding. The former, being the readier and yielding the quicker return, we take first.

Improvement by selection.—We have already stated that an improvement of the ginning outturn is a fact which appeals most readily to the cultivator in that the increased value of the produce is directly apparent in the increased price obtained for weight of kapas. It is here, as might be expected, that the largest practical results have been obtained. These results have so far been confined to the Aligarh district where one of us has isolated a type which gins out at slightly under 40 per cent. The lint of this type differs but slightly from the *desi* type which gins out at about 33 per cent. but the kapas sells at Rs. 10 as. 10 per maund against Rs. 9 as. 3 per maund* for *desi* kapas, an increase almost entirely due to the increased ginning outturn.

The plant is of a robust type with a moderately long vegetative period. It is characterised by a white flower and a deeply dissected leaf and is thus similar to the type recently developed in the Central Provinces.

A series of comparative trials between this white flowered type and the common yellow flowered type of the Aligarh district has given an average of 7 maunds 6 seers kapas for the former against 5 maunds 39 seers for the latter. Calculated on the above basis the improved type gives a money return of Rs. 76 against Rs. 54 as. 14 per acre—an increase of 40 per cent. The above outturns are for irrigated land only and it is probable the difference, when unirrigated land is also considered, would not be so great. We may safely count on a general average increase of 30 per cent.

We have here a type which fulfils the conditions we believe to be essential to the introduction of a new stock, namely, an

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* See page 51 of this Journal, Vol. VIII.

increased money value of some 20—25 per cent. By its introduction, it may be hoped, not only to replace the *desi* mixture, but to increase the area under cotton in the localities where its introduction is attempted. It is lacking in certain desirable qualities it is true. Thus the lint shows but little improvement over the *desi* lint ; * beyond its white flower which is also possessed by many types of *desi* plant, it has no very marked distinctive vegetative character by which it can be recognised in the vegetative condition.

This type is now being as widely distributed as circumstances will permit and the development is indicated in the following table :—

Area sown.		Acres.
1910-11	...	On experimental scale only.
1911-12	...	400
1912-13	...	1,500
1913-14	...	20,000 (estimated).

It has been recognised that this type does not attain to the ideal of what can be grown in these provinces and that it is merely one step towards that achievement. Therefore any organisation which is adopted should be one which will admit of the substitution of a still more improved type of plant than that at present under consideration, and we are inclined to think that that type will owe its value to an improved quality of the lint.

The recognition of this point has a vital bearing on the means adopted for distribution. The frequency of cross fertilisation has already been noted ; and the effect of this, if allowed to take place between the local cottons and a type possessing a better quality of lint, will lead to a marked deterioration of the produce from the latter. The old adage that the strength of a chain lies in its weakest link applies here and the value of a sample of cotton is that of the shortest lint it contains. It follows that, to obtain the full advantage from improved quality,

* Superfine Bengals of the trade. Valued by the Imperial Institute (*vide* Impl. Inst. Bulletin, Vol. X, p. 363) it is worth $6\frac{5}{8}d.$ – $6\frac{3}{4}d.$ per lb., fine Bengals being $6\frac{5}{16}d.$ In Bombay it has been valued at Rs. 265 per candy with fine Bengals at Rs. 245.

it is necessary that that quality shall be uniform and hence that cross-fertilisation shall be prevented. In practice this means that the improved types should be grown in compact areas and not in isolated fields intermixed with fields of the ordinary types. Where quality is not a factor of importance such precautions are not necessary ; no amount of impurity affects the price of the lint while a small amount will not appreciably affect the yield. Having, therefore, hopes that improved quality will ultimately be attained, we have considered it advisable to develop an organisation which will readily admit of the introduction of types possessing quality under conditions which will avoid their reversion. As we have said, the main condition for this is the growth in compact areas. For this reason we have preferred to proceed cautiously and, in the extension of this type, to develop an organisation adapted to ready extension to other types having improved quality. For this purpose the village is taken as unit. Within this unit area efforts are made to get sown to the improved type an initial area which will be sufficient to supply seed enough to sow the entire cotton area in that unit in the following year. This initial area acts not only as a demonstration farm on a small scale but as a seed farm. In general it is found that cultivators are only too ready to take up a crop which they have seen grown with success in their immediate neighbourhood, and in a year or two it may be confidently anticipated that the improved type only will be grown throughout that area, which now forms not only a self-sufficient unit but one from which a supply of seed can be obtained for wider distribution in the same manner. Once this stage has been reached and the crop established throughout such a unit, that unit village can be left to arrange its own internal seed supply and the energies of the agricultural staff are released for development elsewhere. The seed handled by the department represents, therefore, only that which is used in expansion of the area ; those areas where the crop is established and which are merely inspected from time to time are not taken into account. Such seed as is recovered is distributed in areas where a serious effort is to be made to replace the *desi* crop

and, more scattered, through a wider area in small quantities: the latter being merely experimental with the object of ascertaining prospective areas suitable for further extension. The slow rate of increase in the earliest year (from 400—1,500 acres) is due to the fact that a comparatively large proportion of this area consisted of widely distributed small plots for the above purposes of demostration, etc., and from these no attempt was made to recover the seed.

Present experience has already shown the difficulties which may be encountered in the development of such an organisation. Chief of these is the difficulty in buying back the seed in sufficient quantity. In the early stages of the introduction of a crop which is a distinct advance on that commonly grown, the demand for the produce is so keen, in the face of a limited supply, that the purchase of any quantity of seed becomes expensive. In the process, too, we are brought into contact in general not with a few reliable individuals but with a host of small growers many of whom have disposed of their crop before the produce is gathered, and who are, consequently, not free agents. Complete replacement, throughout a unit, of one type by another is, therefore, not the simple matter it appears. Progress must be slow especially at the first. It is to be hoped, however, that private assistance will be forthcoming eventually from the leading agriculturists of the tracts concerned, who can materially help by undertaking responsibility for the units in which they are particularly interested. Signs are not wanting that development will take place on these lines. Certain influential agriculturists already appreciate the value of growing such a type in compact areas and are prepared to organise the seed supply to this end. We aim, therefore, at replacing, as rapidly and as far as possible, the organisation outlined above, by one of private effort, in which the person possessing the greatest personal interest in the village unit undertakes the maintenance of the crop in a pure state throughout that unit.

A further selection has been made of a yellow flowered *desi* type which possesses a lint of improved quality. This does

not possess the high ginning outturn of the last but depends rather on the quality of its staple to give an increased money return per acre.

			Area sown (acres).
1912-13	...	...	30
1913-14	...	...	450 (estimated).

The organisation used in the distribution of this type is the same as that described above, but a different tract has been selected for its introduction.

Further selections have been made which are now in process of testing on the experimental farms. Of these we may mention two with a very early flowering habit, that is, with a vegetative period of 50—60 days only. These are—

(a) A white flowered *desi* plant, agreeing with Gammie's *G. neglectum* var *cutchica*,

(b) A yellow flowered plant having a naked seed.

The value of a naked seed for the production of cake is undoubted, and it is possible that such seed would fetch a higher price on this account and thus increase the money return per acre by increasing the value of what is, at present, the least valuable portion of the produce.

Both these types are suited to non-irrigated tracts, but they have so far not been tested sufficiently to be distributed to cultivators.

Improvemement by Breeding.—This work has been developed especially at Cawnpore with the object of evolving a type which has, in addition to the qualities possessed by the *desi* types we have considered, a finer and more valuable lint.

The process is, as has been said, slower than the selective process and consequently practical results are hardly to be expected in the short period which has elapsed since the commencement. Nevertheless promise of ultimate success is not wanting.

Briefly stated, the method consists in isolating pure types which possess between them the more important desirable qualities; in crossing these and in isolating from the mixed

progeny a type which possesses the maximum of these qualities. For this purpose a series of types have been isolated and used as parents, including all *desi* types described above, which have been crossed with all the best cottons of India. Unfortunately neither the American nor Egyptian plant is available for this purpose since complete sterility exists between these and all *desi* types. For quality we are dependent on the true Indian cottons with fine lint and which we may summarise as follows :—

Broach cotton.—A plant which does not fruit till the subsequent hot weather and is, therefore, quite unsuited for cultivation in these Provinces.

Hinganghat cotton of the Central Provinces.—This is an early flowering type and has a low yield and a low (25%) ginning outturn.

Nurma cotton.—This is red flowered cotton grown round the temples in these Provinces and from its lint is spun the Brahmanical thread. It is a late flowered plant and yields no lint the first year. It is, however, grown as a perennial and, grown in this way, forms a large shrub. The plant appears now to be almost extinct and seed is with difficulty obtainable.

Crosses between these three types and several forms of *desi* plant have been effected. It has been found that when Broach cotton is used as a parent a considerable degree of sterility occurs in the offspring and on this account these crosses are not likely to be a practical success. In like manner when *Hinganghat* cotton is used as a parent the low yield of the progeny has proved the stumbling-block.

Matters are different, however, when *Nurma* is used as a parent and we have now a series of crosses between the *Nurma* plant and different types of *desi* plant which promise well. The characters of the *Nurma* plant may, therefore, be described more fully. In addition to the late flowering habit dependent on the type of branching, it possesses a red sap colour which declares itself not only in the deep red flowers but in the foliage, which is of a rich red tint. The lint is good, being slightly more than an inch in length, strong and somewhat silky. The ginning

outturn is low being some 26 per cent. only. When crossed with white or yellow flowered *desi* it gives a completely fertile plant which possesses the red colour of the *Nurma* parent. The intensity of the red, however, is definitely diminished, and it is thus easy to distinguish the cross from both its full red and from its colourless parent.

From this cross we have attempted to isolate a plant which possesses the early flowering habit, the high ginning outturn and the robustness and the yield of the *desi* parents and, in addition, the high quality of the *Nurma* lint. In addition we have attempted to obtain the red sap colour of the *Nurma* parent. After what has been said above concerning the advantage of a distinct character recognisable in the vegetative condition, the object of this will be obvious. The inspection of fields sown to such a type will be enormously facilitated. Before the first flowers appear, that is, before any danger of cross-fertilisation arises, the fields can be visited and, by a rapid inspection, it is possible to tell not only whether there has been any adulteration but whether the crop contains any appreciable admixture of rogues produced by chance cross-fertilisation in the previous year, and, in the latter case, the rogues can be removed during the ordinary process of thinning of the crop. No question of compensation, such as might arise when mature and bearing plants are removed, is incurred. The rogues will thus be removed before they can cause further injury to the standing crop. Without such distinctive characters, adulteration and rogues are with difficulty determined only by a careful examination of the lint, that is, after damage to the pure portion of the crop has occurred.

It is impossible to deal here with the large series of forms which have been isolated in the course of these experiments. We may say at once that the ideal combination of characters has not yet been obtained; but, what is more to the present purpose, there are clear indications that such a result is not unattainable. The chief difficulty in these experiments is to obtain a combination of quality with high ginning outturn—

quality alone is readily obtained—and until the conditions which determine this outturn are more fully understood the production of such a combination must remain a matter rather for chance. This question of the factors which determine the ginning outturn is now receiving detailed attention.

Of the results which have hitherto been obtained by such breeding we can mention a few only. Thus we have, growing on a $\frac{1}{6}$ acre scale, a type having the red foliage of the *Nurma* plant and a pink flower, with a vegetative period of about 100 days and a lint fully equal to that of the *Nurma* parent. The lint of this plant has been valued at $5\frac{1}{4}d.$ against $4d.$ for fine Bengals. A larger area must be grown before its capacity to produce a sufficiently heavy crop can be definitely ascertained but we have reason to believe that it will be deficient in this aspect in irrigated tracts. It is deficient in the ginning outturn which only reaches 30—32 per cent., and it may be that this will be sufficient to prevent its introduction on a practical scale.

A second type, similar to the last in leaf and flower colour, is also growing in a pure condition at Cawnpore. It gins out at about 35 per cent., but is somewhat deficient in quality when compared with the last, but much above the quality of fine Bengals. Its value would be about $5d.$ when fine Bengals are priced at $4d.$ It is a very early flowerer and would probably prove suited to non-irrigated tracts. Its yield cannot yet be calculated in figures but the individual plants appear most prolific.

We now possess also a series of types not distinguishable from the *desi* cottons until the fruits open when the quality of the lint is at once apparent. The ginning outturn of these varies between 40 per cent. and 30 per cent., but in all cases further tests are required to establish their qualities as heavy yielders. This group as a whole, however, lack any distinctive vegetative character by which their control under field conditions will be simplified.

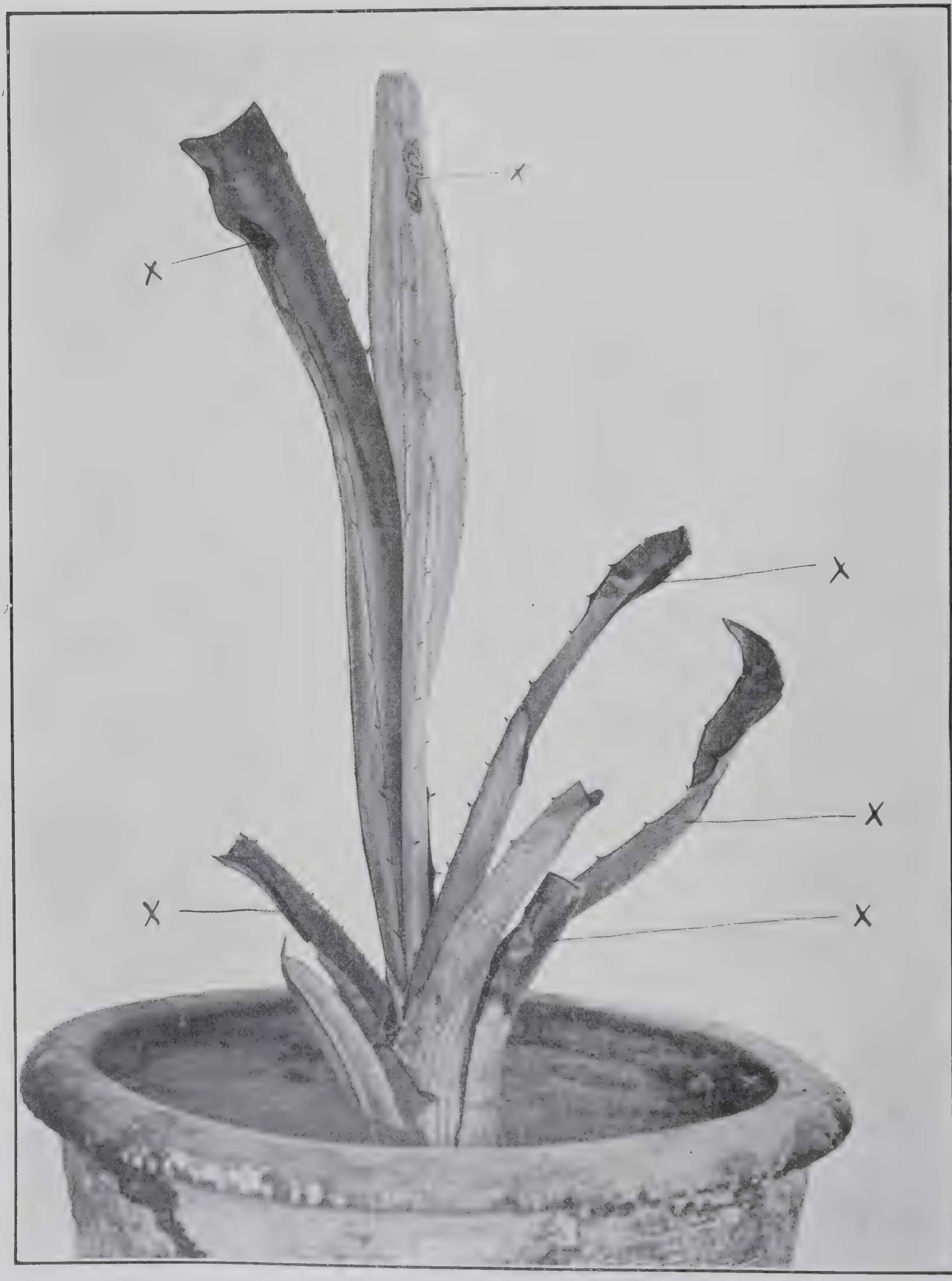
Two points remain to be considered in the process of multiplying these types up to the field scale. During this process it is necessary to reduce their number to a minimum by selection

based on their behaviour under field conditions and, secondly, it is necessary to maintain, at least for a few years, a centre of purity for the types finally selected for distribution. By a centre of purity is meant an area in which the crop is grown under such strict control that a pure seed supply will be guaranteed. This seed will be distributed to suitable centres and lead to a replacement of the crop in the same manner as is already being effected in the case of the white flowered cotton. The danger of deterioration, which has already been referred to when quality of lint is taken into consideration, requires additional precautions, and these are given by the establishment of such a centre of purity from which will issue annually a supply of pure seed tending to counteract the effects of admixture and cross-fertilisation. Such an area has already come into being in the establishment of a seed farm near Aligarh which will, as regards cotton, be used at first to subject the types now in process of evolution to critical tests in the field and later, it is to be hoped, to form such a centre of purity for the types ultimately selected during the early years of introduction.

We have attempted in the above note to describe not only the progress which has been made in the improvement of the indigenous cotton of these provinces, but the direction in which further progress is being attempted. Enough has been said to prove that the problem is no simple one and that the measures which have been adopted to produce a practical scheme, taking into consideration all the complex aspects of the problem, form a reasoned plan of campaign. How far success will be achieved the future alone can say, but whether we succeed or not in our ultimate aim of evolving and introducing into extended cultivation a plant having a greatly improved lint in addition to a high yield and high ginning outturn, we think that we can claim that at least some measure of practical success at improvement has already been achieved, and we hope that the experience gained in the process of breeding new types will not be found entirely unremunerative. Treated purely as a study in plant breeding the problem is highly intricate. We are now well acquainted

with the behaviour of the main vegetative characters of the plant, we know less concerning the behaviour of the fibre but sufficient to be able to obtain plants possessing a good quality of lint with ease. At the present stage, however, we know little concerning the factors which control the ginning outturn which, as we have shown, is a matter of vital importance if practical results are to be obtained. It is on the solution of this problem that we believe most to depend, until which time the production of types with high ginning outturns must remain a matter largely of chance.

PLATE XVI.



A. J. I.

Agave Plant Infected with Colletotrichum, Diseased Leaves marked ×

ANTHRACNOSE OF SISAL HEMP.

BY

F. J. F. SHAW, B.SC. (LOND.), A.R.C.S., F.L.S.

DURING the past eight years specimens of diseased Agave have been received in the Mycological Laboratory at irregular intervals. The diseased plants are invariably affected by a curious blackening and withering of the leaves, which usually begins at the apex and extends down towards the base of the leaf; sometimes, however, the blackened area is restricted to a small circular patch. The diseased portion of the leaf is shrunken, and thinner than the healthy, and, as a result, the cuticle is thrown up into ridges and furrows over the blackened area. In the more recently infected portions of the leaf, the colour is a light brown, which changes as the disease advances to deep black. In the final stages of the disease small erumpent nodules appear in concentric rings.

These symptoms are not at first accompanied by any very obvious signs of parasitic attack. This apparent absence of infection by external organisms, taken in conjunction with the nature of the symptoms, might lead one at first sight to suppose that the cause of the disease was to be sought rather in defective cultivation and adverse climatic conditions than in the attack of any fungal parasite. In German East Africa a disease of Sisal Hemp, which closely resembles that described above, is the cause of considerable loss in the fibre plantations. Braun* states definitely that the disease is due to excessive insolation. He was able to produce the characteristic symptoms

* Braun, K.—Blatflecken an Sisalagaven in Deutsch-Ostafrika. Berichte über Land- und Forstwirtschaft in Deutsch-Ostafrika. Dritter Band, Heft 4, 1908.

of the disease by placing healthy leaves under a high temperature in the laboratory. As a temperature, which under artificial conditions is sufficient to cause disease, occurs frequently in German East Africa, it seemed probable that the source of the trouble had been discovered.

While it is not disputed that excessive insolation, especially when the rays of the sun are concentrated through drops of water, may produce burnt and discoloured patches in the leaf, yet the results of the present research show that the disease which occurs in India is due to the attack of a parasitic fungus.

In 1892 Cavara * described a fungus, which he named Colletotrichum Agaves, occurring on the leaves of species of Agave in Lombardy. A description and illustration of this fungus is included by Montemartini † in his monograph of the Melanconiaceæ. In 1903 Dr. E. J. Butler ‡ noted the association of Colletotrichum Agaves Cav. with a disease of Agave rigida var. Sisalana ; it was not, however, established that the fungus was the cause of the disease. Two years later a disease of cultivated Agave due to the attack of Colletotrichum Agaves Cav. occurred in the Missouri Botanic Gardens. Hedgcock § who investigated the fungus at the Missouri Botanic Gardens, made some inoculations with the mycelium and succeeded in producing the disease in healthy plants. He does not mention any other fungus as occurring in association with the Colletotrichum, a fact which is of interest, as in Guatemala, Kellerman || found a species of Plowrightia associated with Colletotrichum Agaves on Agave americana. The symptoms of the disease were very similar to those described above, acervuli or fructifications of Colletotrichum were developed on the diseased tissue in concentric rings.

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* Cavara, F.—Hedwigia XXXI, 1892, p. 315.

† Montemartini, L.—Ricerche sopra la struttura delle Melanconiee. Atti Istit. Bot. Pavia, VI, 1900, Tab. 12, fig. 10.

‡ Butler, E. J.—Pilzkrankheiten in Indien im Jahre 1903. Zeitschrift für Pflanzenkrankheiten, Bd. XV, p. 44.

§ Hedgcock, G.—Disease of cultivated Agaves due to Colletotrichum. Report Missouri Bot. Gard., 1905.

|| Kellerman, W. A.—A new Plowrightia from Guatemala. Journal of Mycology XII, 1906

PLATE XVII.

A. J. I.

Leaf of Agave Infected with C. Agaves, showing Development of Acervuli in Concentric

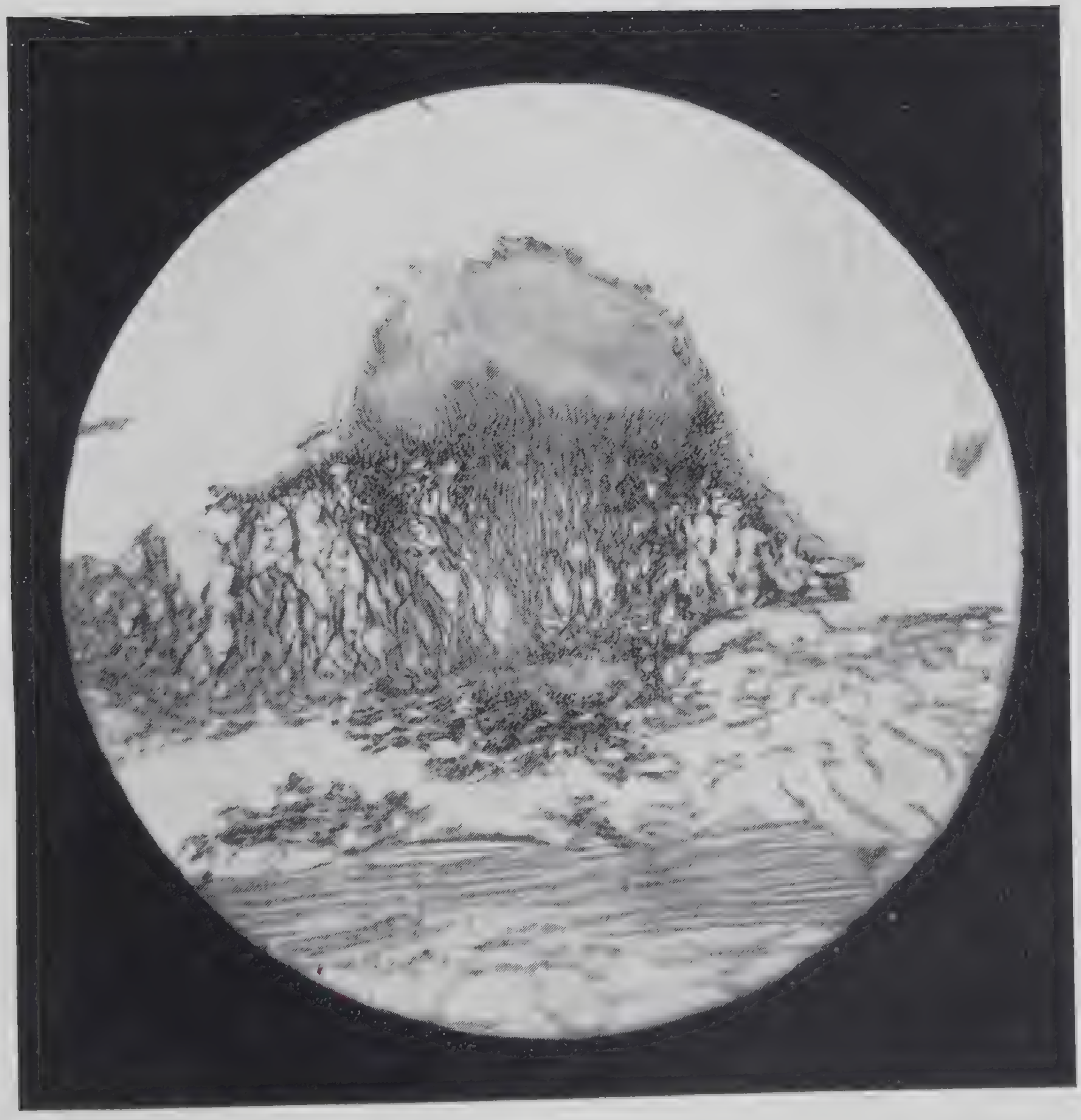
Sisal Hemp infected with Colletotrichum has been obtained from a number of Districts including South Sylhet, Cachar, Assam, Cawnpore and Dacca. In spite, however, of the general occurrence of this fungus on diseased Agave it was not at first believed that Colletotrichum could cause such extensive and serious damage. The arrival of a fresh parcel of diseased leaves from Dacca gave a favourable opportunity for obtaining pure culture of the fungus. Acervuli were cut out from the diseased leaves, and, after having been first washed in sterile water, were placed in agar tubes. Other portions of diseased leaves were flamed in alcohol and incubated in sterile petri dishes. In both cases a white mycelial growth was obtained, which, on sub-culturing on agar, gave rise to a typical culture of Colletotrichum. Hedgcock seems to have had some difficulty in obtaining spores in agar cultures; in our cultures, however, there was an abundant formation of acervuli.

Inoculations were made on small specimens of Agave growing in pots. In the first series of infections the leaves were wounded by making a small cut, tangential to the surface, and a minute piece of agar culture was inserted into the wound. The first result of infection is a blackening of the tissue at the immediate seat of infection. From now onwards the disease follows one of two courses according as the host plant succumbs easily or resists the attack. In the first case the whole leaf turns yellow, the change in colour spreading out from the seat of infection (Plate XVI). As the disease advances, the yellow colour changes to black and small black acervuli of Colletotrichum are produced; in most cases the acervuli are distributed in concentric rings. The whole leaf eventually becomes shrunken and dry, the cuticle being thrown into a series of ridges and furrows. If the host plant resists the attack of the fungus the progress of the disease is much slower. In this case the damage is confined to the portion of the leaf immediately around the seat of infection (Plate XVII). In this small area the tissues become black and shrunken, so that an irregular depression arises on both surfaces of the leaf. Acervuli are produced in concentric rings, as in

the more extensively diseased specimens. A section through the diseased leaf shows hyphæ of Colletotrichum ramifying in all directions through the tissues. If the section includes a fructification the hyphæ are seen to collect and form a thick mass of pseudoparenchyma at the base of the acervulum (Plate XVII). From this pseudoparenchyma the hyphæ grow upwards in a brush-like tuft, and finally, burst out through the ruptured epidermis as a mass of conidiophores bearing spores. In those cases in which the diseased portion of the leaf is restricted to a small area surrounding the seat of infection, a section through the junction of diseased and healthy tissue shows a layer of cork cells across which the hyphæ do not penetrate.

Other infections were made in which pieces of agar culture were laid upon the uninjured upper surface of the leaf; none of these were successful. It looks therefore as if Colletotrichum Agaves was a wound parasite requiring some damage to the host plant before it can produce infection. Nor indeed, when we remember the thick cuticle of Agave, is there anything surprising in the inability of the fungus to penetrate the uninjured surface. It is not unusual to find longitudinal cracks in the leaves of Agave, especially after a period of hot dry weather, such breaks in the superficial tissues would afford a ready means of infection from air-borne spores. Collecting and burning diseased leaves and spraying with Bordeaux Mixture are methods which should prove efficacious in checking the disease.

PLATE XVIII.



A. J. I.

SECTION THROUGH LEAF OF AGAVE SHOWING ACERVULUS OF C. AGAVES.

PRELIMINARY NOTE ON THE OCCURRENCE OF ACIDITY IN HIGHLAND SOILS.

BY

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Agri. Chemist to the Government of Bengal,

AND

A. G. BIRT, B.SC.,

Dy. Director of Agriculture, Assam.

Our attention was drawn to the occurrence of well marked acidity in highland soil both at Dacca on the stiff red old alluvium, and at Jorhat where the soil is still old alluvium but more sandy, when considering the infertility of these soils, which is most marked during the cold weather.

The possibility of the existence of a high degree of acidity in such highland and often well drained soils, is one which up to now has perhaps not received the attention it deserves in those tracts in India where conditions climatic, etc., generally might be supposed to tend to soil acidification. The common idea that an injurious degree of acidity is confined to low-lying marshy or peaty soils is wholly erroneous, as our work on some highland and quite well drained soils proves.

We have reason to believe that the occurrence of such a degree of acidity as is positively injurious to many cultivated crops is far more widespread in N.-E. India than may be commonly supposed.

This might be explained on the grounds that these soils may have been originally formed from rocks more or less deficient in basic ingredients ; and that the amounts of lime, etc., present in these soils originally, have been subjected to gradual but certain diminution, by removals in drainage water

in a region of heavy rainfall, and by the constant withdrawal in crops of basic ash ingredients which exist as neutral salts in the soil.

The preferential leaching of lime is well known; when this process has gone far enough to establish a certain degree of acidity the conditions set up favour the increased removal in drainage water of other plant foods notably phosphoric acid, so it comes about that acid soils are generally more or less deficient in phosphoric acid, and respond to its suitable application.

Most cultivated crops prefer a neutral or very faintly alkaline soil, but it so happens that some crops are more tolerant of acidity than others, that is to say, when grown in an acid soil they make fair or even good growth while others either succumb or make very poor stunted unhealthy growth.

The fact that some crops do well on acid soil is no proof that they therefore prefer it to a neutral or faintly alkaline one, or that they would not do better on the latter kind of soil; it is a question of competition in nature, and it is simply because they have a greater, and other plants a less tolerance towards acidity, that the latter succumb and the former are given an undisputed field, hence in many cases giving rise to erroneous conclusions.

It is possibly this fact which has tended to divert attention from the undoubted evils that soil acidity exercises in the case of many cultivated crops, and has probably caused the failure of certain crops, and not of others, on this class of land to be ascribed to other than the true cause, failures being attributed to lack or excess of moisture, bad germination, fungus attacks, etc., in ignorance of the real reason underlying it. This happened early on in our own experience at Jorhat when an entire failure of the oat crop on land which produces fair crops of *Aus* paddy, and which before sowing the oats had a good dressing of cowdung, led us to suspect lack of soil moisture as the cause.

Examination proved that this was not the case. The seeds germinated perfectly and grew to a few inches in height.

then suddenly turned yellow and died out. The top 6 inches of soil was in quite good physical condition and there was plenty of moisture within 2 inches of the surface, and conditions for aeration are in this soil first class.

A crop of *mati-kalai* sown at the same time not only germinated but gave poor to fair crops. In view of all these considerations we were driven to seek another cause and found it was located in the acid condition of the soil. Analysis showed a deficiency of basic ingredients to which the accumulation of compounds toxic to the plant may be attributed, and as a further result of which soil acidity accrues. It does not follow that the toxic compounds are themselves acid, yet it appears probable that in view of the remarkable action of lime on these soils the toxins are either acids or acid compounds, and moreover they are probably only formed or at least able to accumulate to a dangerous degree in soils very deficient in carbonate of lime.

Recent work, not yet completed, has disclosed the presence in these soils of an organic compound acid in character, definitely toxic to certain seedling plants, but the noxious character of which in such cases is minimised or entirely negatived by addition of lime to neutrality. This laboratory work agrees entirely with field observations and fixes the characteristic infertility of these soils, with respect to certain cropping, as due, largely to a definitely toxic organic compound, acid in character, the evil effects of which may be largely, if not entirely, overcome by the use of lime.

It is well known that lime brings about many changes of a chemical, physical and biological character in soils; most soils contain sufficient lime to supply the food requirements of crops for this substance, and we have figures which prove that one of its least actions on our soils is as a direct source of plant food. We are convinced also that comparatively little of its action is to be ascribed to physical changes, at any rate at Jorhat.

That it induces very much improved biological conditions is evident in the very much healthier tone and darker green colour of crops which follow its application. Probably its greatest function is the establishment of sound healthy soil

conditions by its action on the noxious acid compounds present. It is highly improbable that nitrification is entirely suspended on these acid soils, yet it is possibly so far reduced that plants cannot obtain, in the form of nitrates, all the nitrogen which they require, hence those crops which depend for their nitrogen supplies chiefly on nitrates suffer more from an acid soil condition than others which have the power of drawing upon other combinations of nitrogen to a greater extent.

Our early experience with oats, previous to the sowing of which a heavy dressing of cowdung was given, but no lime, and which still failed to produce any crop, proves that acid soils are entirely uneconomical of manuring; it is in agreement with universal experience that the most economical soils are those which are neutral or faintly alkaline.

It is highly probable, considering the nature of these soil toxins, that deep cultivation and thorough aeration combined with the growth and incorporation of green crops will tend to improve matters, but it will take much time compared with the rapid action of lime, and moreover on many soils the addition of some lime would seem to be almost a necessity to secure even a decent green crop for turning in.

Our experiments up-to-date tend to show that the neutralising effect of lime dressings is not exerted to any great extent below the depth to which it is mixed with the soil during the ordinary process of cultivation. That this is true may be gathered also from Rothamsted experience; during the 18th century and earlier repeated "chalking" with chalk rock drawn from 10 to 12 feet below the surface, was practised there. To-day, it is stated that lime carbonate is only found in the surface soil. Moreover, judging from the cropping to date, our results indicate that for most common field and garden crops, it is not even desirable that the acidity should be neutralised to any very great depth, but that if the soil be limed sufficiently to render the cultivated depth very faintly alkaline, so far as immediately succeeding crops are concerned, it is not only needless, but possibly occasionally harmful, to apply more lime than will ensure this.

Though the applied lime may subsequently not be found to any great extent except in the surface soil and to ordinary cultivation depth, still this does not preclude its action extending further down, because the passage of soluble bicarbonate of lime downwards during drainage can still bring about flocculation, precipitation and other changes in its path, and this constant leaching of bi-carbonate is a well known phenomenon ; laboratory proof of such action on the sub-soil is already in our possession. The deeper the cultivation, of course, the more lime will be needed to neutralise the acidity, because the added lime will thereby be spread over a larger volume of soil.

While our results so far thus show that it is probably better practice and more economical of lime to apply only such quantities as will render the soil faintly alkaline to the ordinary cultivation depth, they also prove that to apply any less quantity than will ensure this, is not enough to produce full crops, and that though lime be applied in smaller quantities at intervals, ultimately the soil must be rendered faintly alkaline to the depth of cultivation practised. Lime should be intimately mixed with the soil as soon as possible after application ; otherwise its full early effect will not follow, and a dangerous degree of local alkalinity may be set up.

For ordinary agricultural practice it should, we think, be kept fairly near the surface. The amount of lime which it is safe or advisable to use depends, of course, on a number of other considerations besides the degree of acidity, and the depth of cultivation commonly practised ; such factors as the cropping to be followed, and the continued use of certain artificials, *e.g.*, sulphate of ammonia have also to be considered.

Our work in connection with the lime problem is being extended to include other phases of its use than those briefly touched on above.

For the present, it is enough to point out the fact that acidity does occur in highland soils, in some cases where one perhaps might not expect to meet it, and, to enforce the recognition of the great value of lime as an ameliorating agent.

RING BUDDING.

BY

MOHD. AMIN KHAN, L.Ag.,

Farm Manager, Peshawar Agricultural Station.

In the neighbourhood of Agra, Delhi, Lahore and other large cities in Northern India where fruits are extensively grown, there are groups of expert budding men who are employed by nurserymen as each budding season comes round. Many fruit growers bud their own plants, and peach-growers frequently combine nursery work with fruit-growing. "Chhala" or "ring budding" is the method invariably practised in the propagation of peaches and pears, but some apricots, plums and mulberries are also ring budded. The art of ring-budding is extremely simple, and in India this is certainly the most expeditious and satisfactory method of propagating the fruits named above. The budding of peaches only will now be followed in detail, and the methods of work which are practised at the Peshawar Agricultural Station will be described. The table on page 77 outlines the propagation treatment which other deciduous fruits require.

Preparation of Stocks.—In early November, the land which has been fallowed for some months in preparation for peaches is finally ploughed, levelled and plotted into canal squares. On 15th November, the area is marked in straight rows $2\frac{1}{2}$ feet apart, and drills 3 inches in depth are cut out by the Planet Junior Hand Hoe. The peach stones are planted about 8 inches apart in the lines, and are covered by working soil by the feet into the drills. It is advisable to insert a pin of wood at either end of each line in order to guide workmen

PLATE XIX.

A. J. I

RING BUDDING.

when they are hoeing between the rows, until the seedlings appear above ground. Irrigation will probably be necessary on two or three occasions before the seeds germinate in February, and hoeing is especially advantageous after irrigation. By the 15th May, the seedlings will be 12 or 18 inches in height, erect, full of vigour and ready to receive ring buds.

Budding.—Vigorous shoots 18 inches or more in length, with bark of a slightly rosy hue, and which have been cut from the crown of a healthy fruiting tree provide the best buds. Vegetative growth should not have finished in the shoots : these should be firm but not ripe. In Plate XIX, the method of taking off and placing buds is very clearly shown. The shoot at (1) has its leaves trimmed off fairly close to their buds, and rings of bark have been removed. If the sap is in condition, the internodal rings of bark will be easily removed and the exposed surface of the wood of the shoot will have a slippy, sticky feeling. With the ball of the thumb and the forefinger of the right hand, the ring buds are successively slipped off the shoot by a dexterous pull and outward twist of the fingers. It is not generally the custom to ring the length of the shoot as shown in Plate at 1. More frequently the internodal rings are removed as each bud is slipped off, working from the apex to the base of the shoot. At (2) various aspects of very perfect fistular buds are shown. No. 3 shows a peach shoot with a ring bud correctly superimposed. The bark of the shoot which has been budded has been slipped back and downwards until the ring bud firmly fitted the skinned shoot. The spare point of the shoot has been cut away above the bud. Something has been sacrificed for the sake of the picture at (3) where the bud is placed on a side shoot, and not on the main stem of a young peach seedling, as it should be. Guided by one who has practised the art, ring budding can be learned in a few moments. At the Peshawar Agricultural Station the budding is done by the farm labourers. An expert budder, under favourable circumstances, can bud from 200 to 400 plants per day of 8 hours, and he expects 90 to 95 per cent. of

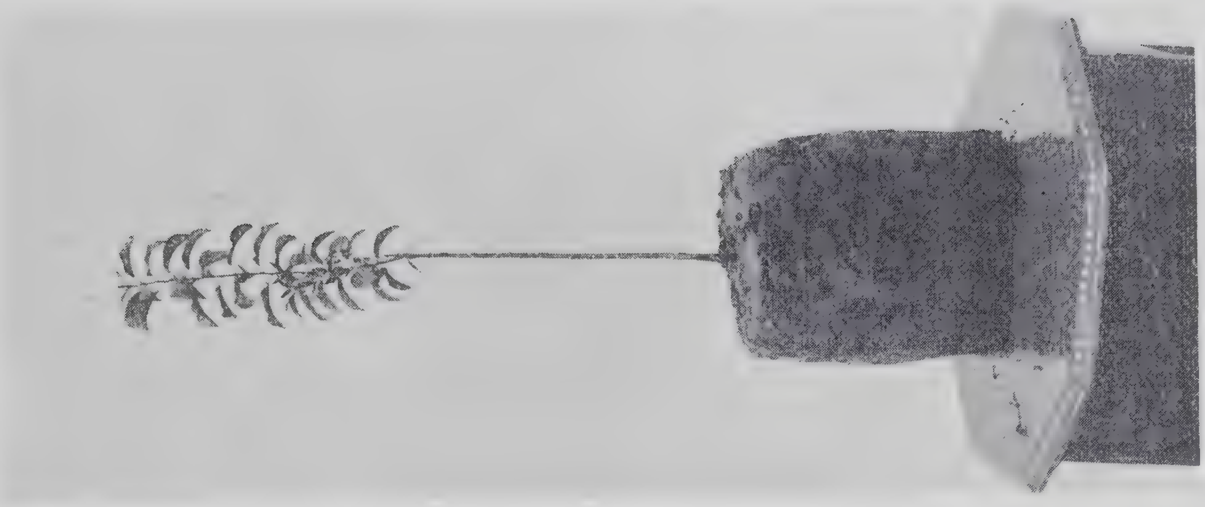
his buds to grow if bright, hot and calm weather prevails for some days after budding. Dull days, with wind and low temperature, are unfavourable to successful ring budding: dewy cold nights just after budding occasionally cause some failures.

Irrigation and Cultivation.—The plots are necessarily rather dry when budding is being performed, so water must be given immediately after the operation, and the soil should afterwards be kept moist until the buds are growing freely. Within ten days of budding, the buds should begin to show signs of growth, and when they are $\frac{1}{2}$ an inch in length the side shoots of the seedling foster-parents must be in part removed in order to conserve the vigour of the seedling in the growing scions. As the buds grow upwards, so must the shoots of the fostering stocks be gradually trimmed off. By the time the scions are 3 inches in length, the side shoots of the foster-parents should be entirely removed. Plate XX shows a ring budded peach plant at six weeks of age, which has been budded too high for general purposes, probably because budding had been delayed until the seedling foster-parent was rather tall. Nursery treatment after the sixth week consists chiefly in encouraging vigorous growth by frequent hoeing and by timely but not over free irrigation. By early November, a good ring budded peach plant is 4 to 5 feet in height and furnished with a useful foundation of side branches. It is fit to set out in the orchard within twelve months of the sowing of the seed of its foster-parent. In its second year in the orchard, it bears a few peaches; in its third year, it should carry a paying crop of between 40 to 60 lbs. of fruits. On Plate XXI an orchard of ring budded peaches is shown. It was planted in December and January 1910-11 after the plants had an extra year in the nursery. At Peshawar Agricultural Station, the Planet Junior Hand Hoe is kept moving in the nursery lines, and the bullock hoe works between the orchard rows. Vegetables of many kinds are grown between the peaches during the first and second year in the life of the peach orchard.

PLATE XX.

A. J. I.
Ring Budded Peach. Age 6 Weeks.

Ring Budded Mulberry. Age 4 Weeks.



Ring Budded Plum. Age 8 Weeks.

PLATE XXI.

A. J. I. AN ORCHARD OF RING BUDDED PEACHES SHOWING THE BULLOCK HOE WORKING BETWEEN THE ROWS.

Ring Budding Table.

Fruit.	Stock.	Date of Planting stock.	Date of budding.	Date of Orchard planting.	Remarks.
Peach ...	Seedling Peach ...	Stones on 15th November.	15th May to 15th June.	15th December to 15th January.	
Plum	Seedling Plum Seedling Peach	Stones on 15th November.	Do.	Do.	For Sandy soil bud on Peach. For heavy soil, use plum stock.
	Plum Cutting ...	15th December			
Apricot ...	Seedling Apricot...	Stones on 15th November.	Do.	Do.	
Pear	Wild Pear "Pyrus Pashia"	Suckers on 1st to 15th December.	Do.	Do.	The wild pear for big pear trees: quince for dwarf trees.
	Quince "Cydonia vulgaris."	Cuttings 1st to 15th December.	Do.	Do.	
Mulberry	Wild Mulberry "Moris indica."	Cuttings on 1st to 15th December.	Do.	Do.	

NOTES.

The Steel Memorial Medal.—At a meeting of the Council of the Royal College of Veterinary Surgeons, held at 10, Red Lion Square, on Friday, October 11th, it was unanimously decided that the Steel Memorial Medal be awarded to Major J. D. E. Holmes, M.A., D.SC., M.R.C.V.S., of the Indian Civil Veterinary Department. The medal, established to perpetuate the name of John Henry Steel, is one of the highest honours the profession can bestow and is always awarded for original research in matters pertaining to the profession.

(The Veterinary Journal, London, November 1912.)

* * *

Co-operative Cattle Insurance Societies.—The subject of Co-operative Cattle Insurance Societies is somewhat akin to that of rural Co-operative Credit Societies in conjunction with which they might be most efficiently worked in India. One great drawback to the poorer class of cultivators keeping good cows is the risk of their death, and if by the payment of a small sum per annum this loss could be recouped to them it would go some way at least perhaps in solving two vital questions of the day, *viz.*, the rise in price of plough bullocks and the rise in price of milk, ghee and other milk products.

Before considering the question from an Indian point of view it will be useful to see what is being done in England among small holders in this connection, and statistics have been lately compiled relating to the 22 registered co-operative societies in England and Wales up to the end of the year 1910, partic-

ulars not being available of unregistered societies of a similar character. The 22 societies had a total membership of 1,631 members varying in numbers from 14 to 331 members, giving an average of 74 members per society. The number of cows and calves insured was 4,588, varying in number from 14 to 1,329, giving an average of 209 per society. Yearly premiums are in most cases about 4/- for cows, the amount payable at death averaging about £10, the premium thus being about 2% of the sum insured. Some societies fix a maximum of £9, £12 or £14 per cow, others pay $\frac{3}{4}$ to $\frac{4}{5}$ of the value without limit, others pay £12, £10, or £8 according as the premium paid is 6/-, 5/-, or 4/-. For calves the yearly premium is generally 3/- after the age of 6 months, the amount payable at death being about £5.

All societies have a rule by which a special levy up to 1*s*. per animal insured may be raised in the event of funds being insufficient to meet the claims during the year, but this is very seldom necessary as most of the societies have accumulated a considerable surplus from which a possible deficit can be met. In addition to the premiums it is usual to charge an entrance fee, the commonest rate being 6*d*., 1/- or 1/6 per cow and 6*d*. or 9*d*. per calf. The proceeds of the hide and carcases valued at about £1 per animal are also credited to the society. The number of animals that died during 1910 averaged 2·2 per cent., during 1911 it was 2·6 per cent., varying from 3·8 per cent. to nil in the various societies.

The members of these societies are mostly small holders, the average number of animals insured being only 2·8 per member and rules are in force in most societies limiting the number of animals which any one member may insure. The societies are managed by a committee, two or three trustees, one or more Stewards, a secretary and a treasurer, the chief responsibility devolving upon the Stewards whose duty it is to pass and brand the animals offered for insurance, to visit sick animals, etc. For these services they usually receive a small fee from the owner, of from 2*d*. to 6*d*. per animal for branding and 1/- or 1/6 for attendance on sickness or at death. Other rules include the punishment by fine

or expulsion for neglect of cattle or for attempting to raise disaffection among members of the society.

As examples of the 22 societies we will take (1) the oldest, that of Mawdesley in Lancashire established in 1807 with 33 members, which insures 53 cows at a premium of 6/- per annum, pays £10 on each cow at death, and has a premium income of £19-10 and a surplus fund of £46; (2) the largest, that of Whixall in Salop, established in 1842, with 307 members, which insures 1,329 cows and calves at an average premium of 3/10, pays an average sum of £7-12-6 per animal at death and has a premium income of £254-2-0 and a surplus fund of £1,176.

The large insurance societies dealing in live-stock insurance charge a premium of $7\frac{1}{2}\%$ or say 5/- on a cow valued at £10 as compared with 4/- in the co-operative societies, the death-rate of cows insured with them averaging about 6% as against about 2% in the co-operative societies. The difference in death rate is accounted for by the more individual care given to their animals by small holders and the less likelihood of having unsound animals admitted to insurance. The difference in rate of premium not accounted for by the increased death-rate is due partly to the Insurance Companies having to put aside nearly 40% of their premium income for expenses of management, agency and veterinary fees, etc.

With regard to the conditions suitable for such a society in India, premiums should of necessity be strictly based on the estimated value of the animal, perhaps 6 pies per rupee equivalent to $3\frac{1}{8}$ per cent. would be about the correct percentage for cows and calves, and 9 pies per rupee or $4\frac{9}{16}\%$ for working bullocks. The *Stewards*, who should be responsible and expert members of the committee should value the animals and the premium should be levied on the sum payable in event of death, which should be not more than $\frac{3}{4}$ths of the estimated value. A small *entrance fee* and also a fee for attendance when sick or at death should be levied at the rate of 4 or 8 annas per animal.

In the same way as the committee of the co-operative credit societies may refuse admittance of any person to the society who,

they think, is not to be depended upon, so the committee of the Cattle Insurance Society would refuse insurance to those who had a reputation for underfeeding or overworking their cattle. It is obvious that in tracts of the country where a scarcity of rain brings a fodder famine such societies could not work, but these tracts are now becoming smaller and smaller owing to the means provided for obtaining grass by rail from long distances. A trial might at least be made in canal-irrigated and sub-montane tracts and parts of the country like Bengal, where there is always enough fodder.

Enquiries have been made from the Registrars of Co-operative Societies of the various Provinces and they report that nothing has yet been done in connection with Cattle Insurance except that in one or two cases the idea has been mentioned at public meetings of those interested as a possible extension of the work.

Since writing the above, I learn from the Registrar of Co-operative Credit Societies in Burma that 23 Cattle Insurance Societies have been formed there, and that they are progressing and working successfully.

From a copy of the byelaws kindly sent to me by the Registrar I find the following are the most important conditions :—

General. (1) The Society insures only healthy bullocks and male and female buffaloes between the ages of 4 and 12 years.

(2) No indemnity is paid in the case of loss from rinderpest or from any contagious disease mentioned in the Veterinary Rules (when the owner has not complied with the rules), riot, theft, straying or railway journey.

Valuation. (3) A member must declare *all* his plough cattle, giving their age, value and description : these will be checked by experts and fixed for insurance.

Premium. (4) A premium of 3 per cent. must be paid in advance in six-monthly instalments.

Deaths. (5) On the death of an insured animal the owner must report the death to, and get it vouched for by, at least two

members or one expert : he will then report to the Committee, who will arrange for the sale of the skin and flesh.

Payment of Indemnity. (6) The Society will pay two-thirds of the insured value of the animal, after deducting the sale proceeds of the skin and flesh, payments being made at the next half-yearly meeting.

Insufficient Funds. (7) If funds are insufficient, the Reserve Fund may be drawn on up to half of its total amount : if funds are still insufficient, indemnities must be proportionately reduced for all deaths during the year.

Reserve Fund. (8) The Reserve Fund shall be formed from (1) fines for non-attendance at meetings, (2) entrance fees which may be levied from new members after the first year, (3) donations, (4) the yearly excess amount of receipts over expenditure and interest on reserve funds.

Veterinary Attendance. (9) If the Committee think that Veterinary attendance is necessary the cost will be paid half by the Society and half by the owner.

Management. (10) The Society shall be managed by the Committee, who shall appoint a Chairman, who shall also be a Treasurer, Vice-Chairman and Secretary, who will give their services gratuitously.

General Meetings. (11) General Meetings shall be held on August 1st and February 1st, at which all business shall be openly transacted ; all members must attend under penalty of a fine of Re. 1.

It is estimated that deaths from other causes than those enumerated in para. 2 will not exceed 5°/ₒ.

Taking a Society insuring 120 cattle worth an average of Rs. 45 each, the annual premium will be 3°/ₒ of 120 × 45 = Rs. 162.

Assuming that 6 animals die during the year and that the proceeds of their carcases average Rs. 8, the net loss to owners is (6 × Rs. 45 − 6 × Rs. 8) = Rs. 270 minus Rs. 48 = Rs. 222 of which the two-thirds part payable by the Society is Rs. 148.

PLATE XXII.

There remains a balance of Rs. 14 to be credited to the Reserve Fund.

Burma having made a successful beginning with these Societies, the time seems to have arrived for Registrars of Co-operative Credit Societies, and others interested in the welfare of the people to take the matter up.—(A. W. FREMANTLE.)

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EXPERIMENTAL FIG DRYING AT SASWAD.—After hearing a complaint from fig cultivators in the village of Saswad, Poona District, that their figs fetch no price after one shower has fallen in June, the writer thought of undertaking an experiment in drying figs locally. Every year big consignments of dried figs are received in Bombay from Turkestan, Smyrna, Greece and other parts, and they are sold at the rate of eight to ten annas a pound.

The writer put up with a cultivator at Amboni, a village near Saswad, and began the experiment in his plantation. The owner was kind enough to allow work in his plot and he also granted the concession of bagging and plucking the fruits at any time. The greatest difficulty about this fruit is that all do not ripen at one and the same time; nor is it allowed to remain on the plants until it is completely ripe, on account of the trouble from beasts and birds, so only half ripe fruits are collected and sent to the market (see Figs. 2 and 3, Plate XXII).

An attempt was made to collect a few seers a day of more developed fruits (see Fig. 4). Still one could not get that degree of ripeness which is recommended in the literature on this process. About 4 seers (38 figs) in all were got the first time and these were dried on a bamboo mat. Every second hour they were turned upside down. In the evening they were brought into the room and again in the morning at 9 A.M. they were exposed. The temperature varied from 91° to 95° F. at 3 P.M., and at 8 A.M. from 81° to 83° F. Again the next day some three seers were added to the lot. The first lot gradually began to contract after three to four days (see Fig. 5), when they were lightly pressed as found in the market. Severe pressing made some fruits burst

and consequently rot (see Fig. 6), so careful handling and pressing was then done. Completely ripe fruits did not yield to the heavy pressing, but only those that were half ripe (see Figs. 2 and 3). In about ten days the first lot became ready for further treatment. This was assured when the fruits did not sink any longer and yielded to the pressure without the least resistance (see Fig. 7). They were weighed and found to be scarcely a seer. In the meanwhile the second lot was gathered. The fruits of the first lot were washed in boiling salt water, the strength being $1\frac{1}{2}$ lbs. to 50 gallons of water or ·3 per cent., and then dried in the sun. After drying it was found that the weight lost was 75 per cent. One seer fresh figs gave one-quarter of a seer of dried figs.

From the above it will be seen that the drying of this fruit, if carefully done, is likely to solve to some extent the difficulty of fig cultivators in the Poona district.—(L. B. KULKARNI.)

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USEFUL MEASUREMENTS FOR LAYING OUT PLOTS.—In laying out an Experiment Farm it is usually necessary to arrange for a number of small plots on which to compare varieties of crops of which only a little seed is available. It is frequently not advisable to make the boundaries of these small plots permanent because of the difficulties in cultivating small areas and because later on it may be desirable to experiment on larger plots. At the same time it is necessary to have a certain number of permanent boundaries such as watercourses and farm roads.

For the United Provinces we have worked out an area of a size convenient for ploughing, which can be divided into small rectangular plots and which can also be divided without much waste of land into larger areas of a convenient shape.

180 feet × 242 feet = one acre.

A plot of 180 feet wide can be easily divided into temporary 1/9th of an acre by leaving a middle road of 4 feet. That gives 88 feet on each side and 88 feet × 55 feet = 1/9th acre.

A plot of land 180 feet wide and 983 feet long allows of sub-division into thirty-four 1/9ths of an acre as follows. Run a 4-feet road up the middle. This gives 17 plots on each side.

17×55	$= 935$
16 temporary roads of 3 feet each	$= 48$
	983 feet.

A plot 983 feet long can also be conveniently divided into four acres as follows :—

242 feet $\times$ 4	$= 968$ feet.
3 roads of 5 feet each	$= 15$ feet.
	983 feet.

Similarly $(13 \times 55) + (12 \times 3) = 751$

751 gives six half acres thus :—

$(6 \times 121) + (5 \times 5)$.

Another useful number is 635.

$(11 \times 55) + (10 \times 3) = 635$

$(5 \times 121) + (4 \times 7' \, 6'') = 635$

(A. E. Parr and H. M. Leake.)

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Feeding for Butter-Fat.—In his article on the General Feeding Characteristics of different classes of stock which forms Part II of the series of articles on the feeding of farm stock, contributed to the Journal of the Board of Agriculture (London), Dr. Crowther of Leeds University discusses what influence feeding has upon the richness of milk. He says :—

"The percentage composition of the milk yielded by a particular animal is largely independent of the nature of the food supplied. Provided that the ration is such that it maintains the milk-yield and general "condition" of the animal, the composition of the milk can in general be but little affected by changes in the nature of the foods included in the ration. Even

in the case of under-feeding the composition of the milk is, as a rule, but little affected until the condition of the animal has been very seriously reduced. Little reliance can be placed, therefore, upon the claims advanced on behalf of certain foods that they exercise a specific influence upon the composition of the milk. The commonest of such foods are malt coombs, palm-nut cake, and cocoanut cake—all of which are said to exercise a specific beneficial effect upon the quality of the milk. There is good evidence that this is true *to a limited extent* of the two cakes mentioned.

"A further exception ought perhaps to be made of the case of very watery foods, such as turnips or brewers' grains, in view of the widespread opinion of farmers and cowkeepers that the quality of cow's milk can be appreciably lowered by the use of such foods. This view has received as yet but little support from the experimental investigation of the subject, which, however, needs to be considerably amplified before the question can be regarded as definitely settled. Long-continued consumption of excessively watery food will probably lead ultimately to a general weakening of the organs of the body and thereby cause a secretion of more watery milk. As a rule, however, the amount of water supplied in the food can vary greatly without diluting the milk. Certainly under ordinary conditions the quantity of milk secreted is quite independent of the amount of water consumed by the animal, the excess, if any, being mainly excreted in the urine and through the skin.

"Although the nature of the food has, in general, little effect upon the percentage composition of the milk, it may have an appreciable effect upon the quality of the milk in other ways, *e.g.*, flavour, hardness of butter-fat and so forth. This fact must be kept in mind in selecting food-stuffs for the ration of cows."

Ability to yield rich milk seems to be an inherited character, and if more butter-fat is to be got from any cow, it can only be done by feeding to get a greater yield of milk of the same

quality. But there is a limit beyond which no higher yield of milk can be obtained by increasing the food-supply as there is an increasing tendency for additional food to promote fattening rather than to increase the flow of milk. This limit varies greatly in different individuals of the same class.—(EDITOR.)

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SEPARATED MILK.—Cream separators are now seen working in many big cities of India. They make a large quantity of separated milk available for use. It is, therefore, desirable that the feeding value of this milk should be known. Separated milk contains about 3·15 per cent. of casein which forms about 80°/ₒ of the total proteid matter of milk and being a nutritious substance, the separated milk remains a valuable article of diet. Separated milk also contains mineral matter and when fed to animals helps in bone formation. Though it contains the whole of the protein of the milk, it is nearly devoid of the fat which should be otherwise supplied. It is employed in the preparation of bread, biscuits, cakes, and sweetmeats. It can be used for calf feeding. The deficient ingredient in separated milk as stated above is fat and to make a perfect calf food some carbohydrate must be added in a form easily digestible by the young animal.—(EDITOR.)

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IN the course of his article on the feeding of farm stock Dr. Crowther of Leeds University says that in selecting the concentrated foods for dairy cows due regard must be paid to their possible influence upon the flavour of the milk, or more particularly the flavour, appearance, and texture of the butter. The following food-stuffs, if used liberally, have a softening tendency upon the butter-fat—rice-meal, maize, oats, wheat bran. On the other hand, a hardening influence is exercised by beans, peas, cotton cakes and meals, and coconut cake. These effects are only appreciable when the food-stuffs in question are used liberally, and may be avoided by using appropriate mixtures of foods.

Musty, mouldy, or otherwise damaged food should be avoided as far as possible, as objectionable taints may easily be imparted to the milk. So far as the influence of the food upon the flavour of the milk and butter is concerned, good pasturage stands unrivalled, carrots are probably the best of the root crops, oats the best of the cereal grains, and rice-meal or maize germ meal the best of the cereal offals.

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SUGAR FROM MAIZE.—A paper on the above subject by Mr. G. N. Blackshaw, Agricultural Chemist to the Government of Rhodesia, appears in the *Rhodesian Agricultural Journal* for October 1912. It seems that a factory for manufacturing sugar from maize was established in France about 1850 and large quantities were actually made, but the project failed owing to the development of sugar beet.

More recently Mr. F. L. Stewart, in Pennsylvania, has shown that removing the cobs from the stalks when in the "milk" stage, results in an accumulation of sugar in the stem, and he has advocated the manufacture of sugar, alcohol, and cellulose simultaneously—involving the utilisation of the whole plant, stalk, leaf and ear.

Mr. Blackshaw has, therefore, conducted experiments devised to determine the sugar content of varieties of maize grown in Rhodesia and the effect of removing the cobs. His analyses show a great variation in the sugar content of the stems of different varieties when the cobs were allowed to mature, but the differences are reduced by the removal of the cobs, which, the experiment shows, caused a rapid concentration of sugar in the stem during the first week after removal, culminating about the sixth week,—apparently at the same time that the cobs on the rest of the crop matured.

The percentage of sugar in the juice of the decobbed stalks cut at this time varied between $12\frac{1}{2}$ and 14, and the glucose between ·9 and 1·1 per cent. The amount of solids not sugar in the juice was generally over 3 per cent. The maximum quantity

of sucrose extracted by the mill used, was 7 per cent. of the weight of the stalk. These results do not appear discouraging when the great variability of the maize plant and its adaptability to development in different directions by selection are taken into account. If successive crops of maize could be utilised in cane sugar factories, it would mean a valuable extension of the season.

Analyses made by Dr. Leather at Pusa in 1911 showed that the proportion of sucrose to weight of stem may rise as high as 9 per cent. in Indian maize, but this represents that recoverable by chemical extraction, not by crushing.

It is probable that in India's shorter season the concentration of sugar would culminate more rapidly, and as to this the time of maturity of the cobs on the main crop should be some guide to experimenters.—(A. C. DOBBS.)

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FLEAS ON HORSES.—The study of Medical and Veterinary Entomology is so constantly bringing to light new relationships between diseases and insects that it is becoming increasingly important to collect every scrap of evidence regarding the occurrence of these latter, and biting insects of all sorts should be collected wherever possible. Whilst on my way to Kollegal in July last I noticed that a *jutka*-pony at Maddur (in Mysore) was infested with large fleas which literally swarmed all over the upper part of its head and neck. As the host seemed to be an unusual subject for the attack of fleas, specimens were collected and have been determined as the Dog Flea (*Ctenocephalus canis*) by the Hon. N. C. Rothschild. So far as I know, this flea has not previously been known to attack horses, so that the record becomes of interest. Neveu-Lemaire ("Parasitologie des Animaux domestiques") states that the Human Flea (*Pulex irritans*) may occasionally attack horses, but otherwise these animals seem remarkably free from flea-attack, so far at least as the *Pulicinæ* are concerned; several species of *Sarcopsyllinæ*, however, are known to attack them.—(T. BAINBRIGGE FLETCHER.)

THE FEEDING OF COCONUT CAKE TO MILCH COWS.—(Jour. South-Eastern Agric. Coll. Wye, No. 20, 1911, Mr. S. Skelton.) An investigation was carried out on the College Farm during the months of April and May, 1911, to determine the suitability of coconut cake as a food for the production of milk and butter. Three cows, which had calved about two months previously, were selected, and, after being fed for a fortnight on an ordinary ration, were given a diet containing coconut cake, the quantity fed being at first 2lbs. a day and gradually increased to 6lbs. per head daily. The total period in which the coconut cake was fed was three weeks, after which the cows were kept under observation for a week, during which time they received ordinary foods. The coconut cake appeared to produce very little effect on the yield and quality of the milk, and on the Reichert number of the butter, though in view of the shortness of the period and the small number of cows it is impossible to draw definite conclusions. It was clear, however, that the cake made the butter much firmer, and it is suggested that on this account it should prove useful as a food in warm weather when difficulty is experienced in making firm butter. (From the Journal of the Board of Agriculture Vol. XIX, No. 7, October, 1912.)

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THE FLOWERING OF THE MANGO.—Referring to a note by Mr. Tamhankar, that appeared in Part IV, Vol. VII of this Journal, Mr. Hartless, Superintendent of the Botanical Gardens at Saharanpur, has sent us a note of his experience with regard to the flowering of the mango, from which the following is taken :—

"The flowering of the mango is a subject to which I have given some attention for the last two years especially ; particularly with regard to those under cultivation in these gardens, where we have nearly 100 varieties.

There is no disputing the fact that there are a few varieties that are irregular in their flowering period, the cause of which it is difficult to ascertain. I have known such abnormality in the ordinary Bombay even, due to a local injury in the first

instance and perpetuated to some extent. But I have not been able to test if this periodicity was hereditary or not.

The variety Baramashi has, as its name implies, the reputation of fruiting all the year round, but here in Northern India, it rarely fruits more than twice a year, the controlling influence being undoubtedly climate.

Personally I have never heard of any *variety* that flowers normally every year. Most *trees* will flower every year more or less, the amount depending on the condition of the trees, and the extent of their productivity the preceding year. If we can get *varieties* with this fixed character of normally flowering every year, we shall solve what is at present a great drawback in mango cultivation.

The real test is to see if the character is hereditary or not. I am of the opinion that it is not, and that a change of climate and environment would show the instability of this character.

Out of nearly 60 varieties observed in 1911, the difference between the earliest and the last to commence to flower was only 25 days. The earliest to commence to flower in 1912 was what we call Bombay Dr. King, meaning that it was received from Dr. King when he was Superintendent of the Royal Botanic Gardens, Calcutta. This commenced to flower on the 20th of February. The latest to commence to flower was Kachmahua, which it did on March 20th.

The first six varieties to flower were :—

Bombay Green,	Bombay Dr. King,	Bulbulchashm,
Davies' Favourite,	Nayab,	Singapuri.

The last six to commence to flower were :—

Hathijhul,	Kachmahua,	Moradabadi,
Nucka,	Pyasee,	Sharbati Brown.

It is interesting to compare the average time that these plants remained in flower.

For the first six (earliest) the average duration of flowering was 30 days.

For the second lot of six varieties (latest) the average was only 12 days, showing a difference of 18 days in the flowering

period of those which flower early in the season and those which flower later. The inferred cause is the increase in the temperature for the period of the year.

In the year 1911, which was a bad year, owing to untimely rain spoiling the flowers or preventing pollination, the averages were 17 and 9 respectively for the six earliest and the six latest to flower, showing a difference of 8 days.

For 1912, the average flowering duration for 58 varieties was 16 days, whereas that for 33 varieties observed in 1911 was only 11 days. As in the latter year the flowering period was most probably shortened by rain at the time, the figures for 1912 may be taken as more nearly correct.

It may here be remarked that the year 1910 was what may be called a "lean" year, and the natural inference was that 1911 would be a "fat" year, but owing to rain at the time of flowering spoiling pollination, it was one of the worst on record. Then, in 1912 the mango crop was one of the largest ever known, following two bad years, one of which was due to what we may call an inherited habit and the other to injury. This should tend to prove the contention that alternation in bearing is primarily due to over-production, with a consequent exhaustion, followed by recoupment. It may not be out of place now to give some further analysis of Mango flowers, that I have made this last season, and which may also possibly serve as a basis for classification.

The points taken into consideration were :—

(*a*) Colour of the flowers.

(*b*) Colour of the flower stalk.

(*c*) Length of the panicle.

(*a*) and (*b*) have been divided into the predominant colours, and (*c*) according to the length of the panicle,—short equal to 4″—8″, medium equal to 8″—16″ and long 16″—20″ long. The varieties are arranged in tables under the respective characters. These tables are given in the hope that other investigators will take the matter up. In this way we may hope ultimately to find a more stable basis for classification than that suggested in the note on this subject that appeared in the last issue of this journal."

MANGOES.

Colour of Flowers.				Colour of Flower Stalk.			Length of Panicle.		
Brownish yellow.	Greenish yellow.	Reddish yellow.	Greenish white.	Green.	Reddish green.	Red.	Medium.	Short.	Long.
Alphonso	Bhurdas	Krishna Bhog	Naspati	Alphonso	Bombay yellow	Bhadaurea	Bhurdas	Alphonso	Arbuthnot
Arbuthnot	Bombay green	Langra large		Arbuthnot	Bombay Calcutta garden	Calcutta Amin	Bombay green	Bhadaurea	Fajri long
Bhadaurea	Brindabani	Romani		Bhurdas	Fajri long	Davies' Favourite	,, yellow	Bombay Calcutta garden	Faqirwala
Bombay yellow	Chickna	Sharbati black		Bombay green	Faqirwala	Fajri round	Bulbulchasm	Brindabani	Gopal Bhog
Bombay Calcutta garden	Ennurea	Sufaida No. 2		Brindabani	Gola	Kachamitha	Calcutta Amin	Davies' Favourite	Hathijhul
Bulbulchasm	Faqirwala			Bulbulchasm	Hathijhul	Kachmahua	Chickna	Kutna	Kachamitha
Calcutta Amin	Gopal Bhog			Chickna	Krishna Bhog	Kistapal	Ennurea	Lamba Bhadra	Kakaria
Davies' Favourite	Hathijhul			Ennurea	Kutna	Punia	Faizan	Naspati	Kala
Faizan	Kachmahua			Faizan	Langra large	Romani	Fajri round	Sunder Shah	Kistapal
Fajri long	Khajya			Gopal Bhog	Najibabadi Amin	Sandurea	Gola		Madras
,, round	Madras			Kakaria	Sharbati black	Sufaida No. 2	Kachmahua		Najibabadi Amin
Gola	Malda			Kala	Singapuri	Surkha	Khapariah		Punia
Kachamitha	Moradabadi Amin			Khapariah	Sufaida No. 1		Khajya		Romani
Kakaria	Nucka			Khajya	Strawberry		Krishna Bhog		Sandurea
Kala	Pyasee			Lamba Bhadra			Langra		Sharbati brown
Khapariah	Salibunda			Langra			,, large		Sharbati black
Kistapal	Sharbati brown			Madras			Malda		Singapuri
Kutna	Sunder Shah			Malda			Moradabadi Amin		Sufaida No. 1
Lamba Bhadra	Strawberry			Moradabadi Amin			Nayab		,, No. 2
Langra				Naspati			Nucka		Stalkart
Najibabadi Amin				Nayab			Pyasee		Strawberry
Nayab				Nucka			Salibunda		
Punia				Pyasee			Sunahra		
Sandurea				Salibunda			Surkha		
Singapuri				Sharbati brown			Tamancha		
Sufaida No. 1				Sunahra					
Sunahra				Sunder Shah					
Stalkart				Stalkart Tamancha					
Surkha									
Tamancha									

Short equal to 4″—8″
Medium ,, ,, 8″—16″
Long ,, ,, 16″—20″

REVIEWS.

Die Züchtung der landwirtschaftlichen Kulturpflanzen, Volume V (Paul Parey, Berlin, 1912).—The increased activity during recent years in the improvement of crops, which has followed the rediscovery of Mendel's law, has shown the necessity of a new type of handbook. Investigations dealing with such problems require information of a kind which is not to be found in the usual works of reference. For example, in studying a new crop, the first problem which confronts the plant-breeder is the difficulty of classifying and subdividing the existing varieties so as to obtain pure material as a starting point for his investigations. The varietal differences involved are so small that the information to be obtained from even the most detailed flora is of little or no use. The plant-breeder's classification only begins where that of the systematist ends. In a similar manner, the information required on everything which concerns the flower must be much more precise and definite than that necessary to the ordinary botanist. The smallest details concerned with the floral mechanism and with the periods at which the anthers and stigma ripen may be of immense importance both in actual hybridization work and also in considering the possibility of maintaining an improved variety. This publication, of which the fifth volume is now under review, was designed to supply this want. The first four volumes deal with the agricultural crops of Europe and contain a concise and clear account of all that is known concerning the varietal characters of these crops and their constancy, the floral mechanism and biology of the flower, the frequency of cross and self-fertilisation as well as a short account of the results obtained up to the present by hybridization

and by the various methods of selection. In many cases, practical details are given of the methods and technique which have been successfully adopted in hybridizing and in selecting the particular crop under discussion. References are also given to all the important literature.

Some of the most widely cultivated Indian crops such as wheat, maize and tobacco have already been dealt with in the earlier volumes on account of their position in European agriculture. The present volume, No. V, deals with tropical and subtropical plants only and includes most of the remaining Indian crops of importance such as sugarcane, rice, cotton, coffee and many others. Professor Dr. Fruwirth, the editor and author of the largest portion of the first four volumes, is also the editor of Volume V, but, in this case, owing to the distribution of the crops described, a large number of other authors have participated. In nearly all cases each crop has been dealt with by an investigator who is himself concerned with the improvement of that crop ; for instance, the chapter on the improvement of sugarcane has been contributed by Van der Stok, the Director of the Java Sugar Experiment Station. This adds very materially to the value of the information and also gives the book a vividness and a wealth of practical detail which could be obtained in no other way. Attention may be drawn to the articles on sugarcane and rice, the first by Van der Stok and the second by Fruwirth and Van der Stok, which are both excellent. These articles together with that on cotton by Leake are by far the most comprehensive, and show that in these three crops a great deal of progress has been made. The number and value of the chapters emanating from the Dutch Colonies, namely, the articles on rice, sugarcane, cacao, coffee, cassava and groundnuts, reflect the great attention which has been devoted to the improvement of crops in their tropical possessions by the Government of the Netherlands. In many cases the information available on the crops dealt with in this volume is still scanty, but it is hoped that this will be remedied in later editions and that new chapters on other crops will be

added. The publication of the book will in itself stimulate research and draw the attention of workers to those portions of the subject on which the existing information is most meagre. In India, where so much attention is now being paid to the improvement of crops and where it is not always possible to obtain all the literature required, such a book will prove invaluable and will be of the greatest assistance to all engaged in plant-breeding.—(G. L. C. H.)

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Die Fauna Der Deutschen Kolonien. Reihe V. Heft. 4; Die Schaedlinge der Baumwolle. Von Dr. G. Aulmann, Berlin, 1912. Price, 5 marks.

Preceding parts of this publication have been noticed in these pages (Vol. VII, page 411). The fourth and latest part, consisting of 166 pages illustrated by 120 text-figures, is devoted to the insect-pests of the cotton-plant in the various German Colonies. Many of these pests are very widely spread throughout the Tropics and some thirty of those mentioned in this pamphlet are to be found in India either as identical or closely-allied species, but this number, it may be added, includes many which are only destructive to cotton-seed. The account of each insect includes references to economic literature, description of the insect, geographical distribution, life history and damage done, and remedial measures.—(T. B. F.)

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Publications of Provincial Agricultural Departments.

Bombay.—The second part of a bulletin on the *Seed Supply of the Ahmednagar District* by Mr. G. D. Mehta, deals principally with the seeds of kharif crops. On the whole, the cultivators in this district appear to select the best seed for sowing purposes and to preserve it well, though the cleaning leaves much to be desired. Cotton seed, however, which is always bought from shopkeepers, is usually very inferior, and the author insists on the necessity of establishing some kind of enlightened control over the supply of seed of this important staple.

A bulletin by Mr. Burns and Mr. Patwardhan on *The Treatment of Grape-vine Mildew* completes a series on this subject. It has been found that careful pruning, removal of old bark and periodic spraying with Bordeaux mixture and soap are most successful in preventing the attack of mildew.

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Mr. G. N. Sahasrabudhe who has spent two years in the West Indies studying sugar manufacture, is the author of an interesting bulletin on *Muscovado Sugar Machinery*.

He advocates the adoption of the Muscovado process for the manufacture of *gur* in India, in factories costing from Rs. 70,000 to Rs. 1,00,000 to erect and capable of dealing with 10,000 to 12,000 tons of cane in the season. A good *primâ facie* case is made out for considering the establishment of such factories likely to be profitable, and details of the cost, working expenses, and probable receipts are given, purporting to shew that with *gur* at Rs. 120 per ton and a sufficient supply of cane within a four-mile radius, such a factory would earn from 40 to 60 per cent. on the capital invested.

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Bengal.—The April number of the *Quarterly Journal* issued by the Bengal Department appears somewhat late.

In the principal article Dr. Jenkins gives an account of some "Observations on the shallow water Fauna of the Bay of Bengal made on the Bengal Fisheries Steam-trawler, *Golden Crown*, 1908-1909."

There are notes by Mr. Woodhouse and Mr. Ghosh on the flowering of sugar-cane in Bengal and on cross pollination and variation in Italian Millet (*Setaria italica*); and by Mr. Smith on the results of seed selection on the yield of maize at Kalimpong.

A short note by Mr. B. Palchoudhuri contains some remarkable statements in connection with the introduction by him during the last 10 years of Australian (Shorthorn and Ayrshire) bulls among ordinary Bengal cattle. These bulls roam about

according to the custom of the country and remain in good condition. The cross-bred bullocks appear to be highly appreciated for draught purposes, beating the Bengal bullocks "hollow, in drawing the cart or plough."

The cross-bred cows, when properly fed and cared for, have given up to 9 seers of milk a day, but their chief recommendation is that they continue milking for a much longer time than the ordinary Bengal cow. On the other hand, the cross-breds are more delicate than the ordinary cattle and require better feeding.

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Assam.—The Assam Department of Agriculture has published in the form of a bulletin a *Note on Manures* contributed by Mr. Meggitt to the discussion of that subject at the meeting of the Board of Agriculture in 1911. The results, detailed in the bulletin, of experiments in Assam, appear to justify Mr. Meggitt in his conclusions that the greatest promise lies in the better use of the indigenous organic manures—cowdung, oilcake, and bones, and in the extension of green manuring.

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Madras.—A similar note by Mr. Harrison on *The Indigenous Manures of Southern India and their Application* is published by the Madras Department. Price 6 pies.

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Central Provinces.—Corresponding information for the Central Provinces is given in a note by Mr. Clouston in the October number of the *Agricultural and Co-operative Gazette* published under the orders of the Director of Agriculture and the Registrar of Co-operative Societies, Central Provinces and Berar.

The September number of this Gazette is a particularly good one and contains among other articles one by the Commissioner of Berar in which he suggests that members of the District Agricultural and Industrial Associations should form semi-philanthropic companies for the growth under expert supervision, and for the sale of seed of improved cotton; an undertaking

which has been proved on the Akola Government Farm to be exceedingly profitable. Figures are given, founded on the experience obtained at Akola, which shew that a profit of 11 per cent. on the capital invested, might be expected; and it is suggested that if the members of such companies would agree to be satisfied with, say, 6 per cent., the remainder might be used in popularising other agricultural improvements. In consideration, apparently, of such a self-denying ordinance, the Central Provinces Administration would endeavour to find trained men to take charge of such farms.

In a series of suggestive notes in the same number, the Registrar of Co-operative Societies lays down some of the principles which should guide the issue of loans to members of Societies in the Central Provinces, and leads up to a set of "Draft byelaws for a Co-operative Insurance Society for Plough Cattle" which should form a useful basis upon which to draw up the articles of other similar Associations in India.

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The *Quarterly Journal of the Indian Tea Association* contains, among others, a note by Dr. Hope on a method of renovating old tea bushes by pruning, and articles by the same author on the value of Leguminous Trees in tea gardens and on the use of artificial and chemical manures.

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A leaflet entitled *Hints on Grafting*, issued by the Bombay Department of Agriculture, contains short instructions on grafting, with simple clear illustrations and should be useful to anyone who is unable to obtain skilled assistance, in multiplying good varieties of fruit trees.—(A. C. D.)

MAUZA ASLPUR.

Map showing the scattered nature of five individual holdings in the Hoshiarpur District, Punjab.

The areas of the holdings are respectively :—

	Acres.
Black	15·55
Yellow	27·83
Brown	9·48
Pink	11·25
Green	10·01

THE CONSOLIDATION OF SCATTERED HOLDINGS.

THE evils of scattered agricultural holdings in India and the desirability of employing official agency to consolidate such holdings have been recently urged by Raja Pyari Mohan Mukharjee, President of the Swadeshi Mela, in his speech made by him at Calcutta on the occasion of the opening ceremony of the Mela on 14th September 1912. The Raja is reported to have said as follows :—

"The most formidable obstacle in the way of agricultural reform is the smallness of ryotty holdings. In several districts the number of ryots holding less than an acre of land is legion, while the holdings of others which vary from five to ten acres or more, comprise a number of plots situated as often as not in different fields at distances of several hundreds of yards from one another. Such a state of things involves great loss of time and labour, it renders all economic arrangement for drainage and irrigation of land quite impossible, and it involves the ryots in endless disputes regarding ingress and egress of water to and from neighbouring plots. The evil becomes much greater when the holding is further divided and sub-divided by the operation of the laws of inheritance, and two or more co-sharers have a joint tenancy in each of the small plots which originally belonged to a common ancestor. These evils have been remedied in Japan by converting all small holdings into compact farms by exchange, addition and deduction of lands held by different tenants and creating a number of peasant proprietors, the farms and areas of whose lands are controlled by an Agricultural Bureau appointed by the State."

Though this, so far as we are aware, is the first public utterance in favour of official intervention, the evil in question, both as regards tenants and as regards small proprietors, has long been recognised in India. In those mines of interesting information, the Appendices to the Famine Commission Report of 1880, will be found a paper by Sir Charles Elliot and Sir Edward Buck in which these well-known authorities wrote as follows :—

"It is an evil from an agricultural point of view that the land of each holder should be broken up and separated (for, even if the proprietor does not cultivate himself, he has to give his tenants broken holdings), and it would be a great advantage to distribute cultivators' holdings as far as possible by blocks."

The Japanese practice was brought to notice in an article by Mr. Shearer in this Journal in January 1908, and the issue of October 1912 contained a note on the corresponding practice in Austria. Mr. Keatinge also, the late Director of Agriculture in Bombay, in Chapter III of his recent work on the "Rural Economy of the Bombay Deccan," and in his lecture delivered to the Society of Arts on the 16th January 1913, regarding "Agricultural progress in Western India," has examined the characteristics of the "economic holding," and has recognised the economic loss due to holdings being scattered in different portions of a village. Most persons acquainted with rural India must be aware of cases in which the scattered character of holdings has been the cause of much loss and discontent, but hitherto there has been, so far as we are aware, no definite scheme put forward for Government interference in the matter.

Indian students of agricultural economy, when looking outside India, have usually turned their eyes to England, which of all countries in the world affords the most unsuitable basis for comparison with circumstances in India. Our Indian students have seldom paid attention to the countries of Central Europe where the character of the holdings and the relations of Government to agriculture are much more akin to what they are, or should be, in India. The recent advances in Japan have, however, attracted the attention of many Indians as they have that of Raja Pyari Mohan Mukharjee, and as Japan has borrowed most of its improvements from Continental Europe, it is to be hoped that we have at last begun in an indirect manner to feel the influence and example of nations like Germany and Austria in matters of agricultural economy. The system of consolidating holdings was introduced in Japan as lately as the year 1899, but it has been known in Continental Europe in some form or other from the 16th century onward, and great use has been made of it since the individualization of agricultural economy caused by the great reforms of the first half of the 19th century. In France the process under consideration has been less used than elsewhere owing mainly to the greater tenacity of *laissez-faire*

principles in that country, but something of the same kind was recognised as necessary in Scotland and England in connection with the well-known series of Enclosure Acts. In Germany the consolidation of holdings was originally undertaken in connection only with the partition of common land, and it is still usual in that country to combine the operations for consolidation of holdings with those for the division of common land and the buying out of servitudes. We find the question of consolidation naturally enough mixed up, as it is in Raja Pyari Mohan Mukharjee's speech, with the question of the small size of holdings (morcellment), and the question has also its relations with other interesting subjects, such as the open field system, the system of mutual cultivation and that of enclosures, but for the purpose of the present paper it will be well to deal only with the proposals which have been made for the improvement of scattered holdings by consolidation.

There appears to be consensus of opinion in Europe that consolidation is economically a sounder condition of things than dispersion, and the action taken in the various countries of Europe towards this end has been conveniently summarised by Roscher in Chapter 78 of his *National ökonomik des Ackerbaues* (1903). Detailed accounts of the measures introduced for this object in Sweden, Germany and Austria will also be found in Bulletins of the Bureau of Economic and Social Intelligence recently issued by the Institute of Agriculture at Rome. We have not in England any definite term for the process in question which is sometimes described as 'adjustment,' sometimes as 'consolidation,' and sometimes by the terrible word 'restriping,' none of which terms has yet been definitely recognised in English technical literature. The German language on the contrary has a number of regular technical terms for the process, and the economists describe it by numerous synonyms such as Verkoppelung, Zusammenlegung, Arrondierung, Kommassation, Konsolidation, Feldbereinigung, and the like.

In most countries we find attempts made from time to time to effect the object in view by voluntary arrangements. Whether

the State is prepared to go further or not, it can at least encourage voluntary exchanges, as in Austria, by a total or partial exemption of such exchanges from Stamp and Registration Duties. In France it is said that the first Napoleon contemplated the exemption from Registration fees in such cases, but even this step has not as yet been taken and the affection of the French legislature for the process of consolidation has never ripened into any actual assistance. In Austria a law of 1869 goes so far as to allow the opposition of a mortgagee in a case of voluntary exchange to be overridden on reasonable grounds by competent official authority.

Such voluntary exchanges, however, as we know in India, go a very little way towards solving the difficulty, and, just as in most parts of India the State steps in to give official help in the partition of joint holdings, so in Central Europe the State considers it its duty to step in to give official help for the consolidation of scattered holdings.

The first step employed in Central Europe is for the officials to be approached by petition from the persons interested, and it is generally laid down that action will be taken only on the application of a certain proportion of the proprietors in the village. The actual proportion differs in different States, and has differed in the same State at different times. Sometimes a fixed proportion of the owners, by number, is considered sufficient. Sometimes this is qualified by requiring the applicants to represent a certain proportion of the area or of the rateable value of land in the village. As a rule, the proportion fixed is one-half or two-thirds, and the most suitable arrangement would appear to be something on the lines of that adopted by the Hanoverian law of 1842 which requires an application from the half of the number of persons interested on the understanding that these persons represent two-thirds of the area and two-thirds of the land revenue of the village, an arrangement which avoids giving excessive influence either to numbers or wealth. When the requirements of the law in this respect are too exacting, as for instance, in the Bavarian law of 1861 which requires the

applicants not only to be four-fifths of the number of owners in the village but to represent also four-fifths of the area and the revenue, the result is that little or no use is made of the law. It would be possible no doubt to allow a redistribution to be made of the property of those persons only who make the application, but apparently an arrangement of this kind has nowhere been introduced, the universal rule being that the whole area of the village should be made subject to redistribution. In some cases too the application may be vetoed for reasons given by the officials and in some States the officials may order redistribution independently of an application for special reasons, such as the necessities of irrigation or drainage projects.

The application having been sanctioned, the next step is to prepare a scheme of redistribution, and in this portion of the process there are great technical difficulties to be overcome, but to anyone acquainted with the procedure followed in partition cases in India, these difficulties should in this country not be found insurmountable. Where it is impossible to provide new land of exactly equal value with the old, the difference is sometimes made up by cash payments and in some cases such payments are limited to a variation of 10 per cent. from the value of the previous holdings. Special classes of cultivation such as gardens, vineyards, etc., are often left untouched, and an attempt is always made to give to each holder a class of land to which he is already accustomed. Pasture land, for instance, is not given to holders who have hitherto been entirely agriculturists and *vice versâ*. Existing mortgages and permanent tenures are left as far as possible unaffected. Tenancy questions, such as we are acquainted with in India, are not prominent in Central Europe, but if the process of consolidation were introduced in India, the consent of the landlords would doubtless be required for a consolidation of tenants' holdings, just as it is in some parts of India already required for their partition. The main object of the process as carried out in Europe is to get each proprietor's land into one block or into as few separate blocks as possible. In Sweden, the law for a long time went so far as to insist on each

holder being given one block only, but the provisions of the law were subsequently so altered as to admit of two or more blocks in certain circumstances. All controversies arising in the course of the process of consolidation, including controversies regarding civil rights, are left, in Austria, to the decision of the officials carrying out the consolidation, appeals being at the same time allowed to be made by parties interested. The expenses of the process were originally shared, in Prussia, according to the advantage gained by each holder or, where this advantage cannot be ascertained, according to the value of his property, but there would appear to have been some difficulties with regard to the division of expenses on this basis, and a law of 1875 has fixed the cost of consolidation at a certain definite sum per acre dealt with. In Japan, the State itself contributes largely to the expenses of the process, and in 1909 the sum spent by the State under this head was reported to have exceeded £25,000, a sum which is said to have constituted one-fourth of the total expenses connected with agricultural administration, for the year, in that country.

There is one aspect of the case which has been pushed further in Europe than is likely to be the case in India, and that is the inducement caused by the consolidation of holdings for owners and tenants to leave the central village site, and live on the newly constituted holdings. In India as in Europe different tracts have different habits in this respect. In some the agriculturists are wedded to the village habitation. In others they already live each in his own holding. The enthusiasts in the cause of consolidation point out that when all the agriculturists are huddled together in one village site, they are exposed to much bickering and strife, to numerous petty thefts, and to the ravages of fire and infectious diseases, that they lose the value of true family life, that their cattle are not properly housed and so forth. They admit no doubt that when the people are together in a village site, police arrangements are easier, and they also confess that there are greater facilities for carrying out small repairs and petty operations by village artisans. At the same

time they are convinced that it is better on the whole for each family to live upon its land, and under the influence of this principle the law in Sweden has been so worked that during the last century more than one-third of the cultivators have been induced to leave their village sites and migrate to their own holdings. It is probably true enough that economically the scattered form of residence is more advantageous, but it is of course an open question how far the Government in any country would be prepared to exert any pressure to induce people to abandon habits to which they are wedded as regards their residence.

Apart, however, from any question of actual residence on holdings, much has been said in favour of the scheme of consolidation in itself. The advantages of a consolidated holding are already acknowledged by the Government in this country in those provinces where its orders in the matter of partition of joint holdings encourage the adoption of arrangements by which in the case of partition each owner should obtain his land as far as possible in one place. It is true that there are difficulties when the owner or tenant is attached to his land for sentimental reasons, and it is also true that a scheme of consolidation might conceivably be used (as schemes of partition sometimes are) for the purpose of petty annoyance. There are also cases where a village contains many different kinds of land (some tracts, for instance, being liable to floods and others not), and it would not be fair to require an owner or tenant in some such cases to hold all his land in one tract. In areas, moreover, which are subject to hailstorms, the visitations of hail are of so local a character that there are advantages in having one's holding in several different parts of the village.

Granting all this, however, it is urged that there still remain substantial benefits in a scheme of consolidation. The original object of the system adopted in Europe was to avoid litigation, and an amalgamation of holdings certainly has a tendency in this direction. The procedure was, however, maintained in Europe on account not merely of its effect on litigation, but also of the

agricultural benefits conferred by it. When, for instance, workmen are employed on an estate, it is easier to supervise them if they are all employed in one ring fence than if they are on scattered plots. There is, moreover, even in the case of villages where the agriculturists do not reside upon their holdings, a considerable saving, when the materials and agricultural implements have to be carried to one site only and not to various scattered spots, and a similar advantage is found in the conveying of crops after the harvest. There is also a considerable saving in the matter of ploughing where a holding has been consolidated. It has been calculated in Austria that the expenditure on the cultivation of land increased for every 500 metres of distance by 5·3 per cent. for manual labour and ploughing, from 20 to 35 per cent. for transport of manure and from 15 to 32 per cent. for transport of crops. Another advantage of a consolidated holding is that the occupier is then in a better position to fence his land from the trespassing of cattle, finds it easier to protect it from birds, and is able to undertake certain kinds of improvement such as sinking of wells. Cases occur every day in India in which an agriculturist would be ready to sink a well in his land if the whole area were in one spot. Another and very tangible advantage in the consolidation of holdings lies in the saving, which it entails, of the waste caused by uncultivated boundary baulks. It has been calculated that if a holding of 62½ acres is composed of a single square piece of land, the length of the perimeter is 2 kilometres. If it is divided into four parcels also square, the perimeter is about 4·47 kilometres ; for 10 parcels, the length of the boundary reaches 6·32 kilometres ; for 20 parcels, it is 8·94, for 50 parcels, 14·28 kilometres. From this it can be estimated how much culturable area is wasted by baulks of say one or two yards in width, when the number of parcels in a holding is increased. The general result of a process of consolidation is acknowledged on all hands to be a very considerable saving in the net cost of production.

The authorities give us many instances of the savings which have been achieved by the process of consolidation. One of the

earliest of those noticed is that of a village in Prussia which was unable to pay its taxes and in which Frederic the Great enforced a system of consolidation with the result that in a few years the village was sold for a considerable sum. Instances are given in Roscher's book above quoted of various portions of the German Empire where the increase in value from consolidation has reached 50 or even 100 per cent., where the value of the meadow hay has been doubled, where the cost of labour has been reduced by 2/3rds and so forth. A case is given of a consolidation conducted over 100,000 morgen in Westphalia with the result that the peasants were able to dispense with 287 horses and 16 oxen, while at the same time increasing their cows by 1,197. A case is quoted from Bavaria where the value of land was raised by 64 rupees an acre through consolidation. In Japan we are told that the reduction in the cost of labour caused by consolidation may be put at 20 per cent. and the increase in the output of crops at 20 per cent. Then there is the case quoted by Mr. Keatinge of a village in Saxony with an area of 1,500 acres, 25 proprietors and 774 plots, where the number of plots were reduced by consolidation to 60 and an area of 10 acres saved in the roads and fences alone, with the result that the saving in culturable area at once met the cost of the proceedings (amounting to Rs. 2,000), and steps had to be taken for increasing the storehouses for agricultural produce. Many other similar instances could also be given to show the benefits which have accrued from the consolidation of scattered holdings.

As an instance of the amount of work actually carried out in other countries in connection with this procedure, mention may be made of Prussia where, between 1878 and 1880, 85,000 plots were reduced to 13,000. In the same country in 1898, 147,425 plots were reduced to 34,828, and between 1874 and 1898, 2,953,692 plots were reduced to 760,976. In Weimar, the number of plots was reduced from 479,997 to 55,028, and in Hesse Darmstadt the average number of plots in a holding has been reduced from 14 to 2. In Sweden also proceedings have been undertaken for many years on a gigantic scale, these and

allied operations having extended over 184,000 square kilometres or an area equivalent to two-thirds of the total area of Italy. In Japan the Government has also taken up the scheme in a comprehensive manner and has decided that, in order to improve the agricultural produce of the kingdom, operations must be carried out over an area of 600,000 acres out of which 1/10th has aleady been subjected to the procedure.

In view of the recommendations put forward in Raja Pyari Mohan Mukharjee's speech, it is well for us in India to acquaint ourselves with what has been done in this direction in other civilised countries. Similar schemes have received the attention of several of our agricultural experts, but they have not yet been seriously taken up by the revenue staff or by the agricultural public, and the above notes on the treatment of the subject in Europe have been put together with the object of placing those who are interested in the question in the way of obtaining for themselves fuller data and more extended information regarding the action which has been taken outside India to meet the class of difficulties which Raja Pyari Mohan Mukharjee has so prominently brought to notice.

THE IMPROVEMENT OF CROPS.

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FROM the general standpoint of the improvement of crops the more modern investigations on hybridization are not without interest. In this paper an attempt will be made to indicate the bearing of these investigations on the wider aspects of plant breeding work conducted with the object of obtaining better staples than those now cultivated. At the present time, in many countries, there is a considerable amount of state-aided effort devoted to the advancement of agriculture, and one of the chief activities of the various Agricultural Departments is concerned with plant breeding and selection.

1. THE PRESERVATION OF PURE LINES.

The most modern investigations on hybridization confirm the necessity of starting all plant breeding work from pure lines, the characters of which have been studied adequately. In the present state of knowledge, this is undoubtedly the best material available for the purpose and, consequently, the preservation of

the pure lines for the benefit of future workers becomes an important matter. This is particularly so in countries like India where reliable seed merchants do not exist, and where it is practically impossible to procure varieties of crops even botanically pure. Before hybridization work can be begun in India, it is necessary to make surveys of the particular crops studied and to separate them not only into botanical varieties and finally into pure lines but also to determine with precision all the characters of the pure lines themselves. All this preliminary work necessarily involves the expenditure of considerable time and money. As hybridization work proceeds, more and more pure lines of known gametic constitution will become, as it were, accumulated at the various stations, and the proper preservation of this material is an important matter, and becomes a valuable asset to the Agricultural Department concerned. It is important that it should not be lost and that it should be readily available for future workers in a manner somewhat similar to the way in which, at research centres, libraries of books are handed down to posterity.

The preservation and exchange of pure lines, the constitution of which has been proved, might easily become of very general importance. There is little doubt that hybridization work will, in the future, become in each country more and more restricted to a few centres, and it is very probable that the material of one country may be of use to the workers at centres in other countries. Thus there may very easily be useful exchanges of pure lines in Northern Europe and again in North America. The whole subject of the best means of preserving pure lines of economic plants of known gametic constitution is one which might well be taken up by the next International Conference on Genetics or by the International Association of Botanists.

2. Plant Breeding Stations.

The complexity of apparently simple morphological characters in wheat leaves little doubt that the number of factors

involved in characters of economic importance such as strength of flour, rust resistance and standing power are equally great. This in turn renders the isolation of new kinds, which breed true in all respects, from the progeny of a cross, a matter of greater labour and longer time than was at one period suspected. In addition, many of these characters are subject to the influence of environment, so that both the study of inheritance and the work of breeding improved varieties becomes increasingly difficult. If progress is to be made in the elucidation of the laws of inheritance on the one hand and in the production of improved crops on the other, it seems difficult to resist the conclusion that there can be little or no progress in either direction unless the work is organised in such a manner that it is restricted to a few centres adequately equipped. The publication of the early researches on inheritance, which followed closely on the rediscovery of Mendel's law, undoubtedly stimulated a large amount of hybridization work at agricultural experiment stations, and was the means of raising expectations that the improvement of crops was a simple matter and might be accomplished in a very short period. As a consequence, plant breeding was started at stations as an addition to an already overloaded programme, and the result has been to flood the literature with a mass of superficial results of no permanent value. Whenever plant breeding has been done with thoroughness and on a sufficiently large scale, it has invariably been found that the inheritance of characters is by no means such a simple matter as was first supposed, and the investigations conducted at such centres as Svalöf explain why it is that the numerous attempts at plant improvement made at agricultural experiment stations have not led to any very striking results. There is no doubt that plant breeding work is useless unless it is carried out on a large scale and with great thoroughness. This in turn can only be done effectively at experiment stations, at which this work is made the chief item of the programme. It would be better, therefore, for each country to maintain a few good plant improvement stations than to carry on superficial investigations at many centres.

3. The basis of selection.

The results obtained in a recent paper* have a considerable bearing on selection. It has been shown in wheat that characters, which appear at first sight to be simple, are in reality made up of several factors, each inherited independently of one another. The total number of factors in this crop will, no doubt, be found to be considerable. Natural cross-fertilization has been shown to be much commoner than was at one time suspected, and this supplies the means by which these factors can combine together to form a very large number of wheats, differing from each other by small amounts. The known complexity of botanical varieties in wheat is at once explained by the interplay between the numerous factors rendered possible by natural crossing. Consequently, the wheats of any region and especially those of a country like India, in which agriculture has been practised from time immemorial, supply material, which may well turn out to be a veritable gold mine, for the exercise of systematic schemes of selection. The careful comparison of the offspring of single plants may yield results of great value to the country. A similar state of affairs appears, from our observation in India, to obtain in several other crops in which self-fertilization is the rule. The comparison of the pure lines of these self-fertilized crops offers a line of work which may prove to be of the very greatest importance in agriculture and is moreover much simpler than hybridization investigations. The only difficulties involved are those relating to the interpretation of the results of the field trials in deciding whether or not an improvement has really been obtained.

These results also concern the question of the improvement of plants in which crossing is common. Here there is little doubt also that numerous factors are involved. These, however, have crossed so much among themselves that there has been no opportunity for the production of pure lines, so that the crops are a network of freely intercrossing forms. A large amount of

* Howard and Howard. *Memoirs of the Department of Agriculture in India (Botanical Series).* Vol, V, No. 1, 1912.

systematic selection, extending over a considerable period, is, therefore, necessary before material, in any sense approximating to pure lines, can be obtained. While, therefore, the question of selection in self-fertilized crops is seen to be established more firmly as a result of recent work on hybridization, the difficulties in applying this process with success to cross-fertilized crops appear to be very much greater. Further, the question of the maintenance of the vigour of these latter crops, when grown in pure culture and when crossing is prevented, is a subject which, up to the present, has not received a very large amount of attention.

The maintenance of the vigour of crops in which a certain proportion of natural crossing takes place, is an important matter. As is well known, the result of cross-fertilization is to ncrease the vegetative vigour of the first and succeeding generations and the question arises what will happen if this crossing is prevented in the case of a pure line which has been selected for uniformity and which has been grown subsequently in pure culture. Will the vegetative vigour of such a culture be maintained, if there is no natural crossing or will it be better to permit a certain amount of crossing to take place in such a way that uniformity of product is not affected ? In other words, is the aim to be the prevention of crossing altogether or the regulation of crossing ? It may be possible in selecting crops to isolate two pure lines which yield similar produce and to allow these to cross among themselves so as to secure for the crop the increased vigour which follows this process. Such a matter can obviously only be decided by experiment. In considering this question we must not permit ourselves to be unduly influenced by the demands of the market for certain classes of produce. The requirements of the market are naturally of great importance, but this is not the only factor to be considered by a Government Agricultural Department like that of India whose business it is, in introducing innovations, to look at the matter from all points of view including that of the welfare of the Indian cultivator. It might be no advantage to the cultivator, after the indigenous mixed crops of a tract have been

replaced by a pure line with uniform produce, if this improvement were followed by a diminution in vegetative vigour. The plant itself, which is concerned solely with its own maintenance and reproduction, often under conditions relatively unfavourable, must also be considered. In the struggle for existence it is at least questionable whether such matters as uniformity of product are as important to the plant as the power to grow vigorously and to maintain itself well over an average of years. Looking at the subject as a whole it seems desirable that the scientific basis underlying the selection and growth, in pure culture, of cross-fertilized crops should be very thoroughly investigated. On the results obtained will depend not only the direction in which the crop can best be improved but also the methods of seed distribution which should be adopted.

RABI FIELD EMBANKMENTS.

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Few people are aware that in the upper part of the Nerbudda Valley, a system of *rabi* cultivation exists which is, in its way, unique and which so far as is known is not found in any other part of India.* The soil in those parts of the Jubbulpore and Narsinghpur districts, where this system obtains, is a heavy black clay unfitted for the cultivation either of *dhan* (paddy) or of the superior *kharif* crops, such as cotton or juari ; but it is eminently suited to wheat which is the staple crop of the Nerbudda Valley. The valley here is a level plain, averaging about 20 miles in width and bounded by the foot hills of the Satpuras to the south and by the Hiran and Nerbudda rivers, which flow directly under the great Vindhyan escarpment, to the north. The whole of this tract from north of Jubbulpore to twelve or thirteen miles beyond Narsinghpur, a length of between 60 or 70 miles, is heavily embanked. In the west of the Bilaspur district and in other scattered areas in Chhattisgarh a somewhat similar system is found. In these districts the practice has arisen of turning low embankments in black soil rice fields into larger *Bandhias* (as they are called) for wheat, and similar to the *haveli*† type described above. The *Takavi* loans of 1897 famine greatly extended this practice which enables a fine crop of wheat to be grown in the field itself, and

* A very similar system prevails in the Gaya District of South Bihar.—(Ed.)

† Black soil ract of the Nerbudda Valley.

the rice crops in the field below it to be irrigated when the bank is cut. The sum of these advantages seems to outweigh the potentialities of double cropped rice, which was previously grown in these areas. The system which is described in some detail in this article, however, refers to the Upper Nerbudda Valley and consists briefly in holding up the monsoon rainfall in the embanked fields, which are enclosed on all four sides, and in retaining in the fields the water so impounded until sowing time approaches, when it is let out and the fields sown as soon as the land is dry enough. The system is of very ancient origin and was developed in the very fertile plain to the north-west of Jubbulpore city, where land has probably been embanked for some hundreds of years commencing from the time when the Hindu cultivators from the north first entered the valley and ousted the indigenous Gond. From this centre, the system seems to have crossed the Nerbudda into the Narsinghpur district within more recent times. It also received an extraordinary impetus in the Bijeraghogarh pargana before the Mutiny when the Hindu ruler of that time Raja Prayag Das encouraged his cultivators to embank by the promise of a protected tenure.

The area of the Jubbulpore embanked tract is roughly 200,000 acres, and that of the neighbouring Narsinghpur district is rather less than 100,000 acres, which does not include small separate areas, in which conditions being suitable, this system has also been introduced. The embankments are of two kinds, *viz.*, the *Bandhan* and the *Narbandh.*

Narbandh.—The former which will be discussed more fully later on are typical of the tract and consist of level fields surrounded on each side by an embankment. They become filled by the rainfall alone. The *Narbandh*, on the other hand, is built on sloping land or across a *Nala* and is a much bigger construction. A *Narbandh* is filled by the collection of rain-water from a considerable area. The silt thus brought down in suspension slowly levels up the bed of the *Narbandh*, but this is a very slow process. It is said that a builder of a *Narbandh* does not himself

as a rule, realise the full benefit of his industry in the shape of better crops, but expects his son to do so. As *Narbandhs* are comparatively unimportant in the tract we are discussing, owing to its level nature not necessitating their construction, a further consideration of them may be omitted and a more detailed description of the typical *Bandhan* proceeded with.

The Construction of Bandhans.—In the case of typical *Bandhans* of the Jubbulpore-Narsinghpur *Haveli*, only flat stretches of good soil are usually embanked. These soils are of two kinds and are named *Kabar* and *Mund* each being generally divided into two classes, *viz.*, inferior and superior.

Kabar I is a very heavy black clay containing practically no sand or stony nodules. When dry, it becomes very hard and tough and cracks widely. A fractured lump of dried *Kabar* possesses a glazed appearance. *Kabar II* is a slightly inferior edition of the above. It occasionally contains a small amount of sand, and in that case hardly cracks at all when dry. Other kinds contain small *Kankars* or nodules of limestone, such soil being difficult to distinguish from *Mund*. *Kabar* is in all cases, however, a heavier soil than the latter, is extremely retentive of moisture, but is apt to become hard rapidly, which makes it unculturable unless the seed is drilled just at the right time.

Mund is also divided into a superior and inferior class. It is a lighter soil than *Kabar*, is more free working and always contains lime-stone nodules. In the poorer classes of *Mund* these are numerous and of large size, and the soil is greyer than it is in the case of true *Mund* and at the same time is not so fertile and is less retentive of moisture.

Work on the construction and repairs of embankments is always done in the hot weather after wheat harvest is over. The soil is taken from the inside of the field next to the *Bund* and is dug out in great cubes by means of a crowbar, the blocks of earth being built up one on the other like stones in a wall. A typical old established embankment is a substantial construction, $3\frac{1}{2}$ to 4 feet high and as much as 10 ft. through at the base.

A new embankment requires to be raised about 2 feet at the end of the 2nd and 4th years, after which *Kabar* bunds require little attention for some time but *Mund* bunds, which flatten down much more rapidly, require attention every six years or so.

If the monsoon arrives with a big burst of rain, the embankment is liable to be breached in several places, more especially in the case of *Kabar*, which cracks greatly in the hot weather. If, however, a few showers precede the arrival of the real monsoon, the clay expands, the cracks close up, and there is little fear of a breach. Newly made embankments are especially liable to burst, and in order to strengthen them the cultivator frequently plants the sides with deep-rooted grasses such as *Dhavi (Saccharum moonja)* or *Kans (Saccharum spontaneum)*, while the tops of the bunds are sown with *Til (Sesamum)* or *Mung (Phaseolus mungo)*. *Bandhans* are of all shapes and sizes, some fields may be 50, while others are only 2 or 3 acres in extent. The area and shape depend on the contour of the land to a large extent, slight irregularities in the general flatness of the plain being made use of, and the cultivator, although he possesses no instruments, is rarely wrong in his levels. The size and boundary lines of the different holdings also partly account for the irregularly shaped fields which are sometimes noticed.

Method of Cultivation.—The wheat stubble is uprooted, more or less, by the *Bakhar* (a kind of harrow) at the end of the hot weather, but in some cases even this preliminary cultivation is not undertaken. The bunds are raised, strengthened and repaired in plenty of time before the expected date of the monsoon. If the rains are good, the bunds will fill rapidly in August, as by that time the whole of the sub-soil over a large area has become thoroughly saturated, practically all the rainfall being held up. Heavy rainfall is required in August and September to fill the bunds; if only light, even though continuous, rain falls, the bunds will not fill. All weeds except *Kans* are drowned out, but the latter, unless the water is more than 2 feet deep, flourishes. In August and September it is a common

sight to see the cultivator and his family standing up to their knees in the water, pulling up the *Kans* by its roots. The *Kans* after being uprooted is tied into bundles and together with weeds cut from the sides of the bunds is thrown into the water to rot. Water remains in the *Bandhans* until the beginning of October, and is then run off. The letting out of the water is a gradual process. As has been explained above, the practice of embanking is a very old one in the tract under reference, and the cultivators know by long experience which fields ought to be drained first. A narrow cut is made in the wall of the embankment, and the cut is deepened by degrees to allow the water to escape gradually and to avoid flooding out or scouring the field below. In most fields the portions round the sides, owing to the removal of soil for raising the embankment, are lower than the rest of the field, and are not sown until some time after, as they remain damp much longer.

Kabar soil requires very careful treatment for, if not sown at exactly the right time, it sets hard and becomes impossible to sow. A careful cultivator therefore drains one *Kabar* field at a time and works night and day with all the seed ploughs (*Naris*) he possesses, in order to get his seed in, at the right time. Parts of the Jubbulpore *Haveli*, where *Kabar* is prevalent, present a curious sight at night during the busy season. The *Kabar* fields are ringed round with flaming torches fixed to the ends of long bamboos and placed upright in the soil at regular intervals, while the long string of *Naris* travel in a curved line from one end of the field to the other, the tired bullocks being urged on by loud shouts from their drivers.

Mund does not get out of condition nearly so rapidly, and the sowing of this class of land proceeds much more leisurely. In the Narsinghpur district, it is usual to give *Mund* soil one *Bakharing* after the water has been drained off and before sowing, but in parts of Jubbulpore this is often dispensed with and the *Nari* is put straight on to the land as it becomes sufficiently dry after draining off the water, as it is usually absolutely free from weeds.

The crops grown are the usual *Rabi* ones. The favourite mixture is *Birra* (wheat-gram), the percentage of gram ranging from 12½ to 25% according to the class of soil. Pure wheat is hardly ever grown, as the cultivators say that the presence of gram keeps up the fertility of the soil, thus showing a belief in the renovating powers of leguminous crops. Other common crops are gram *(Cicer arietinum)*, *Masur (Ervum lens)* and *Teora (Lathyrus sativus)*, while linseed is also cultivated to some extent when prices are favourable. *Kabar* is not supposed to be so suitable for wheat as *Mund*, and the percentage of gram in the *Birra* is much higher in consequence. Some of the best *Kabar* land is double-cropped. Early coarse *Dhan* is sown broadcast as a catch crop, and is followed by either *Birra* or gram.

The standard outturns for this tract as given by Mr. H. R. Crosthwaite, Settlement Officer, in his Preliminary Report on the Jubbulpore Tahsil are as follows :—

Wheat	700 lbs.
Gram	700 lbs.
Masur	700 lbs.
Linseed	300 lbs.
Rice (uncleaned)	800 lbs.

The best cultivators in good years raise much bigger crops than these, however, and I have seen many wheat fields which have threshed out at over 1,000 lbs. per acre.

Conditions Essential for the Practice of this system.—Having thus briefly described this system of cultivation, it will be interesting to note the conditions necessary for its practice. The first essential is a level area of heavy clay soil of considerable extent. Unless the area is level, the cost of embanking becomes relatively too great and the area of the land enclosed, which is submerged by water, too small. For this reason this system is not likely to receive widespread acceptance in the Damoh *Haveli* which is somewhat undulating, but where other conditions seem favourable. Heavy soils are necessary to hold up the water.

An analysis of *Mund* soils from an embanked field near Sehora in the Jubbulpore District made by Mr. F. J. Plymen, Agricultural Chemist, Central Provinces, is given below :—

Coarse Sand	0·18
Fine Sand	8·26
Silt	17·12
Fine Silt	24·07
Clay	33·00
Loss on ignition	6·39
Moisture	7·66
Calcium Carbonate	0·13
Soluble in dilute acid	3·19
	100·00

It will be noticed that clay and silt together comprise nearly 75% of the total contents.

The area to be embanked should be extensive and compact. In introducing this system into a new tract, it is seldom much use embanking less than about 100 acres in one place. In smaller areas, owing to drainage from outside the embanked area, the sub-soil will not become properly soaked, and in consequence the *Bandhans* will not remain full. This circumstance has been a source of much difficulty and disappointment where individual landowners or cultivators have attempted to introduce this system. The rainfall must also be good and must be characterised by heavy individual downpours. In both Narsinghpur and Jubbulpore, the rainfall averages between 50 and 60 inches as a rule, and falls of three or more inches within the 24 hours are not uncommon.

Lastly, a knowledge of the management and construction of *Bandhans* is necessary, and mutual agreement among the cultivators as regards the time and order of letting out the water from different fields is essential. In the Hoshangabad district in the year 1902 several blocks of land were embanked by Government on this system to act as a demonstration. The sites were on the whole well chosen, and local conditions of soil and rainfall were good, as the *Bandhans* fill every year. The

people, however, to whom this system is new, do not know how to manage these bunds and have no settled agreement regarding the order of letting out water, so that the demonstration up to the present has been only a qualified success.

Advantages of the System.--One of the chief advantages that obtains with this system is the protection afforded against failure of the late monsoon rains, which are so important in this part for *rabi* sowings. If the rainfall in the early monsoon has been heavy, the bunds fill and a moist seed bed is assured. In the Jubbulpore district, where the system of embanking is a very ancient one, practically all available land is embanked but the practice has spread into the neighbouring district of Narsinghpur only within comparatively recent years, and increased activity in embanking fields has always been shown during a cycle of years in which the late rains have been scanty. The great success of this system in the famine year 1896-1897, when a dry September followed a very wet August was especially remarkable. Mr. C. A. Clarke when Deputy Commissioner of Narsinghpur made an enquiry into the matter and found that from 1866 to 1896 the average rainfall was well over 50″, and that in only one year (1868) was the fall less than 30.″ From 1895-1896 onwards, however, the late rainfall was very scanty. For seven years in succession no rain fell in October, whereas before this period any thing from 3 to 8 inches usually fell during this month. The acreage recorded as embanked at Settlement (1885-1894) was 50,000 acres, and since then this has been increased by 25,423 acres or more than 50%. There is little doubt, therefore, that the cultivators regard embanking as a species of insurance against failure of the late rains, and consequently rapid development of this form of improvement took place during the cycle of twelve dry years following 1896.

Another advantage that is claimed for the system is that fields so embanked become more fertile than similar unembanked land. The fact that weeds, grass, etc., are thrown into the water to rot during the rains is stated to be one of the causes. It is possible, as some authorities think, that the water

in the *Bandhans* possesses more solvent power, owing to the presence in solution of carbonic, humic, crenic and other organic acids resulting from the decaying vegetable matter, and that the rate at which phosphorus, potash and other mineral plant foods are liberated from the soil may be accelerated. There is no proof one way or other as no investigation into the matter has yet been made. On the other hand it would seem possible that the water-logging of the soil might tend to inhibit aerobic bacterial activity to a great extent. Also the percentage of organic matter in the soil does not seem to be very greatly increased. Thus a sample of *Mund* soil from an old embanked field near Sehora in Jubbulpore district was compared with one from a field of unembanked *Maryar* (a very similar soil) in Hoshangabad. Both had been cropped with wheat or *Birra* for a large number of years continuously, and neither had been manured so far as could be ascertained for a very long time if at all. The results were as follows, the analysis being conducted by Mr. Plymen :—

Soil.	District.	Loss on ignition.
Maryar ...	Hoshangabad ...	6·20
Mund I ...	Jubbulpore ...	6·39

The moist seed bed, continuous cropping with a leguminous mixture, and absence of erosion may be sufficient to account for the good results obtained, while the soil, being derived in all probability from the mixed geological formations which are found in the hills surrounding this tract, is probably in itself peculiarly fertile.

Undoubtedly the greatest advantage accruing from this system, however, is in the saving of labour. In the Western half of Narsinghpur and Hoshangabad, where the wheat soils are similar but not embanked ; the wheat grower, in a season with favourable breaks, will give the following cultivation. The stubble is *Bakhared* up during the hot weather, one *Bakharing* is

given after the rains have commenced and is followed by a ploughing. During breaks in the rains three or four more *Bakharings* are given and the field is again *Bakhared* before sowing. In all one ploughing and four or five *Bakharings* are required. On an embanked field in Jubbulpore, on the other hand, the stubble may be *Bakhared* during the hot weather, but no more cultivation is given, as the water in the fields keeps the land free of weeds.

In Narsinghpur the custom is generally to give one *Bakharing* after letting out the water and before sowing the seed. Cultivators in the *Haveli* tract keep far fewer cattle in proportion to the size of their holdings, than in the unembanked areas; indeed instances are not wanting where men in possession of quite substantial areas keep no cattle at all, and merely hire them for the sowing season. The saving of labour is therefore considerable and is, I think, one of the chief causes of the popularity of this system.

Drawbacks.—Having enumerated some of the advantages it is only right to turn to a consideration of the drawbacks of this system. In years of heavy late rainfall the *Bundhans* do not give such good results as the unembanked fields. Last year (1911-12), for instance, two inches of rain early in November delayed sowings very greatly and as a consequence the crops were very late. Late crops of wheat in this tract are nearly always inferior to early sown wheat, and in addition are more liable to the attacks of rust. In the years 1892-95 this disease caused great loss and the late sown wheat of the *Haveli Bundhans* suffered most severely. Rust appeared again in 1911-12 and the late sown wheat of the *Haveli* again suffered more heavily than wheat sown earlier in *Tagar* land.

An incidental disadvantage of this system, which has, however, been avoided in the more recently embanked area in Narsinghpur is the practically complete absence of village roads, and consequently of carts, in the Jubbulpore *Haveli*. All produce is purchased in the village by travelling dealers and conveyed by pack animals on foot-paths along the top of the

bunds to the railway. The absence of carts is especially felt at harvest time as the threshing floors are always near the village, and the whole crop has to be brought in from the fields on head loads sometimes from a distance of two miles. There is little doubt, however, that the advantages largely out-balance the drawbacks, and that the embanked field is a much more valuable asset to its owner in these parts than a field not so improved.

YIELD AND QUALITY IN WHEAT

BY

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In the literature relating to yield and quality in wheat there appears to be a considerable confusion of ideas. As this is likely to stand in the way of progress, an attempt has been made in this paper to define the position in so far as it applies to India. There is a general opinion that in some manner yield and quality are antagonistic and that high yielding wheats are always of poor quality. On the other hand, if quality is aimed at, then the yields are necessarily poor. At a recent discussion on the improvement of English wheat at the Farmers' Club in London these erroneous ideas were advocated by Percival,* who maintained that, under English conditions, yield and quality cannot be combined.

The results of our experiments indicate that there is a definite connection between yield and quality. These experiments

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* *Journal of the Farmers' Club*, 1912, p. 80.

can best be understood and their significance realised if the two aspects of the whole question are separately considered. In the first place, the experimental evidence on the possibility of combining high yield and high quality in the same wheat must be considered. The second point relates to the conditions under which, in any particular wheat, the best quality can be obtained.

The first aspect relates to the combination of yield and quality in the same wheat. On this subject there is a considerable volume of Indian evidence. At Pusa several new hybrid wheats with high grain qualities, raised from Muzaffarnagar, have for several years given higher yields than either parent. These are Pusa 100, 101 and 106, which were tested by Mr. Humphries in 1910 and found to behave like Manitoban good grade wheats produced in a dry season.* Several other wheats from the same cross, which have not yet received numbers, gave equally good results in 1912. In the trials of the strong wheats in 1911, Pusa 12 at most stations gave a higher yield than Muzaffarnagar, a result which is almost always the case when the two wheats are grown side by side at Pusa. In the case of gram (*Cicer arietinum*, L.) at Pusa, where many pure lines have been grown, the line with the highest quality is by far the highest yielder. Experience shows that there is no inherent antagonism between yield and quality, and that both are possible in the same wheat.

Considerable attention has been paid at Pusa and afterwards at Cawnpore to the study of the conditions under which any particular wheat gives the best possible sample. As might have been expected, the best samples were produced when the wheats gave the highest yield. The best samples were obtained after hot weather cultivation and clean fallowing during the monsoon, when the objects aimed at were the absorption of water and its retention in the soil and subsoil combined with the destruction of all weeds. In this way yields of over 40 bushels to the acre

* Howard and Howard, *Bull.* 22, *Agricultural Research Institute, Pusa*, 1911, p. 14.

have been obtained at Pusa without manure, without rain after sowing and without irrigation. The higher the yield, the finer and more uniform the sample has been while the results of the milling and baking tests have always been most favourable in years of greatest yield. Thus in 1910 at Pusa, when the yields were the highest ever reached, the samples were particularly well spoken of by Mr. Humphries and gave very good results indeed when milled and baked. In 1911, the yields due to very unfavourable weather were lower, and in that year the samples were relatively poorer in appearance and the milling and baking results were also to a certain extent adversely affected. In the tests of Muzaffarnagar grown at the various stations a similar result has been obtained. The Cawnpore and Pusa samples have always done best in the milling and baking tests. At these centres this wheat has uniformly given higher yields than at the other stations. There is no doubt, therefore, that in wheat growing the best sample is produced under those conditions which give the highest yield. This in reality clears up the whole matter as will be obvious from the experiments described below. These relate to hot weather cultivation and drainage—two important factors in wheat production in the alluvium.

A. Hot-weather Cultivation.

In previous papers* attention has been drawn to the marked effect of hot-weather cultivation in the production of wheat and other crops, both *kharif* and *rabi*, in the alluvium of the Indo-Gangetic plain. During the early period of the wheat experiments at Pusa, when attention was being paid to the best methods of growing the crop under Indian conditions, it was decided to try the effect of opening up the stubbles immediately after harvest

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* See *Nature*, Feb. 17th, 1910; *Memoirs of the Dept. of Agri. in India* (*Botanical Series*), Vol. III, No. 4, 1910, and *Pusa Bulletin No.* 22, 1911.

and so exposing the soil to the hot dry winds which prevail at this period of the year. The stubbles were ploughed several times and thoroughly opened up resulting in the production of a deep dry mulch of fine soil in which no growth of weeds was possible. This enabled all the early monsoon rains to be absorbed and the subsequent procedure consisted in sufficient cultivation to keep down weeds and to break up the surface so as to allow of the percolation of more water into the subsoil. In this manner sufficient moisture was absorbed for a wheat crop of over forty bushels to the acre and the fields rapidly became free of weeds. In the lighter lands, the water holding capacity of the soil was increased by ploughing in crops of *san* (*Crotalaria juncea*, L.) raised on the early monsoon showers, but this has not yet been found necessary in the heavier lands.*

The effect of hot weather cultivation and moisture conservation was then tried at Cawnpore and, as at Pusa, the effect was instantaneous. The detailed results are published elsewhere and it is sufficient to say that crops of between 25 and 30 mds. to the acre of high quality wheat have been produced using half the quantity of irrigation water employed by the cultivators in the neighbourhood.

At this point it became desirable to determine the actual crop increase resulting from hot weather cultivation. It was unfortunate that both at Pusa and at Cawnpore all the land had been thoroughly cultivated in the hot season for at least two years before the experiment was started and none of the area had been left in its original condition. Under these circumstances it was expected that no great differences would be

* If green manuring with *san* is attempted on heavy wheat lands in Bihar, in years when these soils are water-logged after the green crop is ploughed in, the resulting wheat crop is always less than if no manure had been added. The addition of the green crop seems to accentuate anaerobic fermentation in the soil and to reduce the available nitrogen for the wheat crop. Fortunately such heavy soils retain water well and are not in need of green manure for this purpose. The fact that green manuring these heavy lands for wheat reduces the yield seems to indicate that on rice lands in Bihar green manuring with *san* would increase the yield considerably.

detected the first year, and that it would take some time for the fertility to fall to the ordinary level of that exhibited by the cultivators' fields.

The experiment at Pusa was commenced after the harvest of 1910 and a level plot of typical wheat loam of high moisture retaining capacity was selected for the purpose. One-half was cultivated during the hot weather, the remainder being left untouched till after the beginning of the monsoon. Across both plots a strip of land was manured just before sowing with Nitrate of soda, at the rate of 224 lbs. per acre, and the results are shown in the following plan :—

Ploughed after the beginning of the monsoon.	Ploughed from the hot season onwards.	
32·02	37·89	Unmanured.
35·72	37.52	Manured wlth Nitrate of soda at the rate of 224 lbs. per acre.
32·02	37·89	Unmanured.

The numbers in the table are bushels per acre.

The figures show that late ploughing caused a fall in the crop of six bushels of wheat to the acre, and that the dressing of Nitrate of soda partially made up for the deficiency on the late ploughed plot but added nothing to the yield of the early ploughed plot.

The consistency, absolute weight and nitrogen content of the samples in this experiment are given in the following table. Those manured with Nitrate of soda were darker in tint than the

others, while those from the late ploughed plot were comparatively pale in colour and not so well grown as the rest :—

Treatment of the land.	Consistency.			Weight of 1,000 grains in grammes.	Nitrogen percentage.	Yield per acre.	
	Hard.	Intermediate.	Soft.			Mds.	Bushels.
Ploughed early ...	88	12	0	32·29	2·49	27·62	37·89
Do. + 2 cwt. of nitrate of soda per acre.	88	12	0	31·48	2·57	27·35	37·52
Ploughed late ...	71	29	0	30·91	2·28	23·35	32·02
Do. + 2 cwt. of nitrate of soda per acre.	81	19	0	31·11	2·48	26·05	35·72

The standard maund consists of 40 seers and is equivalent to 82·27lbs.

In the following year, 1911-12, the experiment was repeated on the same plot, but in this case no nitrate of soda was applied. There was a distinct difference in vegetative vigour between the plots and this is reflected in the yield of grain as will be seen in the results obtained.

1. Early ploughing—35·41 bushels to the acre.
2. Late ploughing—22·90 bushels to the acre.

The difference in yield during the past year was twelve and a half bushels per acre, or about twice that obtained the first year of the experiment. The results indicate that the effect of hot weather cultivation is cumulative and that the effects are not lost for some time. The experiment is being continued until the yield of the late ploughed plot becomes steady, after which it is proposed to reverse the treatment of the two plots.

As regards quality, the appearance of the wheat from the late ploughed plot was distinctly inferior to the other. It was paler in colour and not so well grown as that from the early ploughed plot. In this case while the plot with the higher yield gave the better quality, the fall in yield was greater than the difference in quality. This agrees with our experience at Pusa in wheat growing that in the case of the same wheat any adverse condition always affects yield much more than quality. When quality is sensibly lost, it is almost certain that the yield is poor.*

B. Drainage.

During the progress of the wheat investigations in India one important factor in the growth of this crop has frequently been observed. This is waterlogging both previous to and during the growth of the crop. If wheat lands in Bihar are inundated for any length of time during the monsoon, or if portions of the fields are continuously waterlogged for long periods, then a sour or semi-marshy condition of the soil results which is shown by a yellow crop of poor vegetative vigour and low yield. Often the consistency of the resulting sample on such areas is affected and a large proportion of mottled and soft grains are produced, which spoil the appearance of the sample and lower its market value. Similar results are to be seen in canal irrigated tracts in low-lying areas of the fields which get too much water and in which the soil becomes semi-waterlogged for long periods. These effects were distinctly visible in the wheat plots at Bankipore and Dumraon in 1911, where wheat followed

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* In connection with these experiments the behaviour of the continuous wheat plot at Pusa may be of interest. This is a strip of typical wheat land which, for the past five years, has been cropped every year with wheat without manure. In 1911-12, the fifth year of the experiment, the yield per acre was 36·25 bushels, which is the highest yield of the variety (Pusa 22) so far obtained at Pusa. No diminution in vegetative vigour was observed. On the contrary, the growth was so great that a large portion of the crop was laid by wind soon after coming into ear which circumstance diminished the yield of grain. It will be interesting to see for how much longer these yields can be obtained and whether any organic matter besides the stubble need be added to the soil.

rice. The samples also contained a high percentage of soft and spotted grains. Drainage is therefore an important matter in wheat growing in India both as regards yield and quality even in areas where the crop is grown without any appreciable rainfall during the growth period. The long periods of rainless weather in India are apt to distract attention from the necessity of drainage. In reality however, in a country where most of the rainfall is compressed into three months, the necessity of perfect drainage is even greater than in localities where the total precipitation is more evenly distributed through the year.

At Pusa, during the wheat growing season 1909-10, which was preceded by a heavy monsoon, alternate strips of wheat and gram (*Cicer arietinum*, L.) were sown on a plot of heavy wheat land which was imperfectly drained during the monsoon. It was observed that while the gram was exceedingly good the wheat was poor and stunted with yellowish foliage and exceedingly small ears. The total crop was only a small fraction of that obtained on the rest of the field where the surface drainage was sufficient. The markedly different behaviour of a cereal and a legume, growing under the same conditions in the presence of sufficient soil moisture, suggested that the explanation of the difference would be found in the nitrogen supply in the soil. Accordingly the matter was made the subject of an experiment in the following year, 1910-11.

The monsoon of 1910, although well distributed, was small in amount and no waterlogging took place as the showers were absorbed and practically no water drained off the surface. In consequence the land had to be artificially water-logged, and this was done during the month of September by pumping water from the river on to the area under experiment. The land selected for the experiment was well ploughed in the hot-weather of 1910 and fallowed till the end of August when the central portion was embanked and artificially kept wet during the whole of September. After drying sufficiently the water-logged portion was harrowed and ploughed up and managed in the ordinary way till sowing time. Across the middle of the

plots a strip was manured with nitrate of soda just before sowing, the total amount added being four cwt. to the acre. At first the waterlogged area did best due to the abundant moisture, but after tillering it rapidly fell behind the areas on either side. The nitrated strip in the waterlogged area soon became well marked, but was hardly distinguished on the weathered plots on either side. The yields obtained are given in the following plan :—

The effect of waterlogging wheat land at Pusa in 1910.

Normal cultivation.	Waterlogged during September.	Normal cultivation.
34·45	15·55	29·14
SHADED AREA TREATED	WITH 4 CWT NITRATE	OF SODA PER ACRE.
35·92	25·17	26·53
34·45	15·55	29·14

The numbers in the plan are bushels per acre.

It will be seen that the effect of waterlogging for a month was to reduce the yield by about sixteen bushels to the acre while the nitrate of soda on this area increased the yield by nearly ten bushels. The effect of the manure on the non-waterlogged plots, as was expected, was very little. The results prove that the effect of waterlogging wheat lands in the previous monsoon is to interfere with the nitrogen supply of the crop and to lower the yield.

This result is of some general interest in Indian agriculture and particularly in those tracts of the plains like Bihar where

rice and wheat are both grown. The low lying areas in these tracts, which receive drainage water from the higher lands, are generally planted in rice, and these lands are often inundated and always waterlogged for long periods during the growth of the rice crop. The rice plant, however, thrives under these conditions and is able to take up its supply of nitrogen under waterlogged conditions most likely in forms such as ammonia which are not suitable for other crops. In wet years like 1909 in Bihar the waterlogged and marshy conditions associated with rice culture may be said to have spread beyond and above the paddy fields and to have affected the wheat lands. This naturally influenced the soil processes and consequently the supply of available nitrogen for the wheat crop. Gram, however, being able to supply itself with nitrogenous food-material, was not affected and could thrive where a cereal like wheat to all intents and purposes starved.

From the economic standpoint the results of this experiment point to the great importance of drainage in the alluvial soils of India and the need of the limitation as it were of rice conditions to the areas which produce this crop. Where canals are used for watering the wheat crop it is also essential that the fields should be level, so that all parts are equally watered. Where low areas exist, the surplus irrigation water drains into and waterlogs these areas and the result is a small crop of poor quality. On the black cotton soils of the Central Provinces it is often observed that the low lying areas of the wheat fields often yield a larger proportion of spotted and soft grains than those parts which lie higher or are better drained. This partial waterlogging, which is more frequent in the black cotton soils than in the alluvium, is probably one of the chief causes of the unevenness in the consistency of the wheat often grown in Central India. The greater unevenness of the fields in Peninsular India probably follows from the fact that the levelling beam (*sohaga*) does not seem to be in general use in these regions. It is most important from the point of view of the miller that samples should be uniform in consistency otherwise a lower price is obtained for the wheat. The cultivator in

growing wheat of mixed consistency loses twice over. In the first place the yield is reduced and in the second place the quality is affected.

These experiments clearly indicate two of the main factors in the plains on which optimum yield and quality in wheat depend.* If cultivation is inadequate, the yield falls and the quality is also affected. Want of drainage lowers the yield, affects the consistency and also lowers the quality. As regards wheat production it may be said that the best quality is obtained when the optimum yield is produced and that in any particular wheat the ryot who produces the greatest yield has also secured the best quality possible in that wheat. If under these circumstances he grows a wheat in which high yielding power and high quality are combined, he is then getting the greatest financial return for his labour.

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* Another important factor in wheat-growing in the alluvium, in addition to hot-weather cultivation and drainage, may be mentioned. This is the treatment of the subsoil after it has been compacted by the monsoon rainfall. Experiments conducted at Pusa on the last three wheat crops, 1909-10 to 1911-12, have clearly indicated the advantage of a deep-ploughing towards the end of the monsoon. This aerates the subsoil, increases the root-range of the wheat plant and results in a considerable improvement in the standing power of the crop as well as a better filled and more attractive sample. In the crop of 1911-12 the results of late deep-ploughing were particularly well marked. This cultivation must however be carried out without an undue loss of moisture—a matter of some difficulty in certain years with soil-inverting iron ploughs. On large estates it is possible that the best results will be obtained by the use of some form of sub-soil plough.

SOME FOES OF THE FARMER IN THE CENTRAL PROVINCES AND HOW TO DEAL WITH THEM.

BY

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Deputy Director of Agriculture, Southern Circle, Central Provinces.

Owing to the very large area which still remains under jungle in the Central Provinces there is probably more damage done to crops by wild animals in these provinces than in any other part of India. Wild pigs abound everywhere and make nightly raids on cane, *juar*, rice and other crops on which they feed all night returning to their haunts in the jungle in the early morning. One cane-grower lately informed me that his field of thick canes of which he had obtained the seed from the Department of Agriculture was damaged to the extent of Rs. 300 by pig in one night.

2. The counter measures that one naturally suggests in this case are (i) to destroy as many pig as possible, and (ii) to protect the fields by fences. But as the pig is a nocturnal feeder and lies hidden during the day in the jungle or grass-covered wastes which are often many miles distant from the crops on which it feeds, to reduce their number to any appreciable extent will, I believe, take many years. In some districts of the Central Provinces cultivators are granted gun licenses on condition that they shoot a certain number each year. In the North of the Provinces a system of pig hunting with dogs has been organized and some thousands have been killed this season in that way. In villages in jungly tracts pigs are often caught and killed in pits. Otter traps have been tried by the Department of

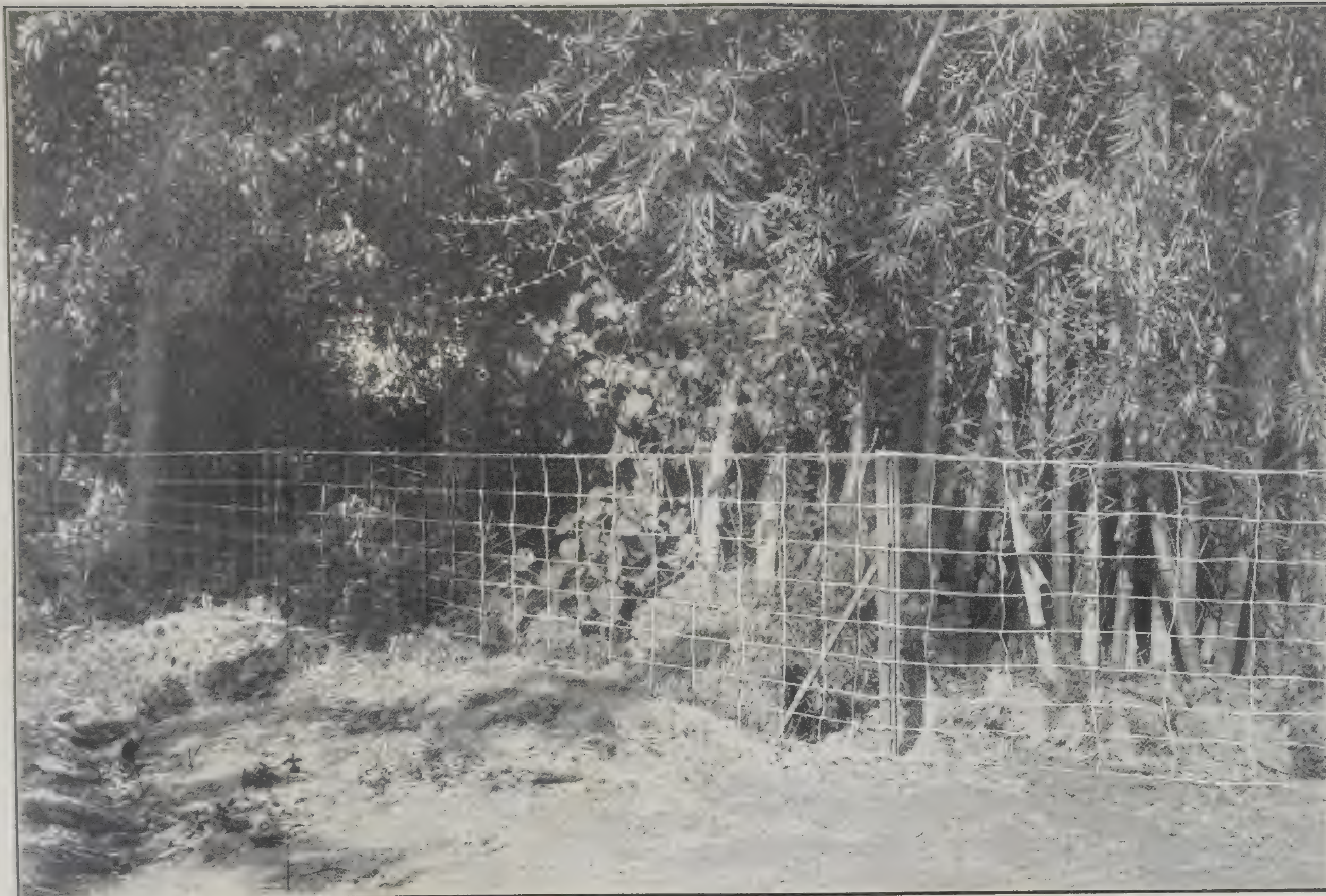
Agriculture and by means of these a few pig have been caught: but while the number destroyed by these different methods may total to some thousands every year, the number of young produced probably amounts to many hundreds of thousands. To obtain immediate and effective results in crop protection, therefore, the use of fencing is necessary, by means of which valuable crops in pig-infested areas can be saved from their ravages. To attempt to grow the thick juicy high quality canes which are so toothsome to pig from a porcine point of view would, in districts where pig abound, appear to be a hopeless task without some such precautions.

3. The types of fencing used locally for cane fields are all more or less inefficient and it is customary therefore to keep also a watcher at night in the fenced field. His wild yells in the silent watches of the night on the approach of "grunters" are generally sufficient to scare them away: but at times, Homer-like, he often nods, and on such occasions the owner finds next morning that thousands of his canes have been destroyed and that his farming profits have been very materially affected thereby.

Where wood is plentiful, it is usual to construct a fence of thorns or bamboos, but on the efficacy of such a fence one never can entirely rely, as both pig and jackal bore their way through it.

Where jungle is distant a mud wall about 3′ in height is constructed all round the field; this is generally effective in keeping out pig if kept in a good state of repair; but jackals do not hesitate to jump over a wall of this height. Not only are the fences in common use at present inefficient but in the long run they are more costly than a *pucca* and permanent fence would be. To fence an acre with the branches of thorns or garari (*Cleistanthus collinus*) costs about Rs. 12 and lasts for one year only. In addition to this the owner has to meet the cost of retaining one watcher for 8 months and the practical certainty of a certain amount of loss. The cost of patent woven wire fencing per acre now under trial is about Rs. 200 and it should last for at least 20 years. Barbed wire fences are quite useless.

PLATE XXIII.



A.J.I.

A Patent woven Fence in Maharaj Bagh Garden, Nagpur.

4. As the problem of protecting cane had become a serious one, I had occasion two and a half years ago to suggest to the firm of Messrs. Burn and Company that they might design a strong woven fencing of the type of wire netting. The firm in reply sent a roll of patent wire fencing known as the Ideal woven fence which had been sent to them on trial from home. Page's fence supplied by Balmer, Lawrie and Co., is similar in construction to Ideal fencing, but the wire is of a lighter kind. Of both these patent fences there are several types varying in height and in the size of the mesh. We have tried several of these in the Central Provinces and have found that a fence about four feet high with a mesh 3 inches in depth at the foot, increasing to six inches at a height of 2 feet is, if properly fixed, quite effective in keeping out pig. For general purposes type No. 1150 of Ideal woven fencing is, as far as I have seen, the most suitable. It is supplied in rolls of 220 yards and costs 8*d.* per yard run. The fence is 50 inches high, and has eleven strands with uprights 13 inches apart. It is sufficiently strong to keep out cattle, sufficiently high to prevent *nilgai* from jumping it and the mesh is sufficiently small to debar pig. If properly stretched, jackals cannot get through it without considerable difficulty.

Patent woven fencing is being successfully used as a deer fence for a park in the Maharajbag gardens in Nagpur in which *nilgai*, *sambar*, antelope and *cheetal* are kept.

The chief points to be attended to in constructing a fence of this kind are (*i*) to see that the lower edge is two or three inches below the surface of the ground, (*ii*) that there is no space left between the lower edge of the fence and the ground, *e.g.*, at *nala* crossings, and (*iii*) that the wire is properly stretched. Nos. (*ii*) and (*iii*) are obvious points, but in the case of fences erected on our experimental farms I have noticed that the staff seem at first incapable of grasping their importance, and almost invariably leave an entrance somewhere. They only learn by sad experience that the habit of the pig on approaching a fenced field is to run along the wire in search of an opening. On several occasions pigs have got into our fenced areas by such openings, and their

destruction when inside has given a considerable amount of sport. A large boar, which recently entered, by a *nala*, the cane area fenced with Ideal woven fencing on the Raipur Farm, after having made many attempts to find an exit, charged and knocked down several coolies and one of the farm staff, and died inside the fence fighting to the last.

No. 1150 Patent Woven fencing described above costs 8 annas per yard exclusive of posts. In jungly districts where it is most required wood can be obtained at low rates and the cost of this patent fencing with wooden posts is approximately the same as that of an ordinary wire fence with iron standards. So as to obviate the necessity of having to renew these wooden posts after a period of years it will be found advisable to plant, between each pair, a cutting of *salai* (*Boswellia serrata*) or some other species which can be reproduced from cuttings. In two or three years these *salai* trees will serve the purpose of permanent posts. This method of fixing the wire is now being tried by the Department and will, I believe, prove satisfactory.

Semi-wild cattle, though of limited numbers and local occurrence, do an enormous amount of damage to crops in the vicinity of the jungles in which they live. The cattle live in herds of from 30 to 70 and there are few districts in the Central Provinces without one or two such herds. By day they are to be found resting in the jungle from which they pay nightly visits to the nearest cropped fields. These herds are no doubt the descendants of strays or of animals set loose as an act of religious merit by Hindus. They are generally in prime condition; are much more alert than domesticated cattle, and are often very furious when irritated.

To destroy these animals would offend the religious prejudices of the Hindus; to construct a fencing that will keep them out of a field is too expensive to be a practical proposition. The only feasible remedy left, therefore, is to capture them. Three methods of accomplishing this have been tried in these Provinces. The first was to entice these animals into a large *kheddah* strongly fenced with fencing of 8 barbed wires on

posts 4 feet apart, each supported by a stay to give it strength. The fence was interlaced, moreover, with thorny babul branches and a trench 3 feet wide and 3 feet deep was dug to prevent the cattle when inside from rushing it. The cattle were enticed inside by *juar* stalks placed inside. Trails of *juar*, salt and cotton seed leading up to the entrance were also put down. The area of 3 acres inside the *kheddah* proved much too large and great difficulty was experienced in approaching the enclosed cattle sufficiently near to lasso them. To throw the lasso for any considerable distance with effect was impossible owing to the number of obstructions in the form of trees. Moreover, when once enclosed, these cattle become dangerous and a man can only approach them in safety by taking shelter in a heavy cart with a hood. This was done and the lasso was thrown from the end of a long bamboo. Even after taking these precautions this method involves much danger for the lasso thrower who is not constantly on his guard. To manipulate the bamboo properly he has to come out of the cart and is liable to be charged at any time. While carrying out this operation for the first time two men were injured by an infuriated bull which charged and gored them. Over 30 animals were captured last hot weather in a *kheddah* of this kind, but we do not recommend it as the most suitable.

The second method that has been tried was to drive the cattle into nets placed in the more open part of the jungle. But this, too, was rather unsuccessful. The excessive exertion entailed on the animals in their efforts to escape resulted in the death of most of them from abortion in the case of cows in calf, and from what appeared to be congestion of the lungs in the case of other animals.

The third and most successful of the methods tried was to construct a very small *kheddah* 40 feet square, of strong wooden posts 3 feet apart and 7 feet high, with cross pieces 1 foot apart. To give this fence additional strength a strong stay was put in behind each post. The cattle are allured inside as described in the case of the previous method and the gate is then quietly

closed by the watchmen in charge. They are then lassoed one by one by men who have taken up their positions in trees overhead. Fifteen were captured in this way recently without much trouble. Plate XXIV shows how this was accomplished. This method is easily the cheapest and most expeditious that has yet been tried and will be adopted in capturing other herds that are still at large.

PLATE XXIV.

Capturing Wild Cattle.

CONVOLUTED TUBE WELLS FOR IRRIGATION

BY

T. A. MILLER BROWNLIE, C.E.,

Engineer, Amritsar Municipality.

Considerable difficulty is experienced in many parts of the country in obtaining a sufficient supply of water from wells for the necessary irrigation of the fields in their immediate vicinity.

Most people are aware that only a limited quantity of water can be taken from any well ; this limited quantity, which is the safe yield of the well, represents a maximum velocity of water passing through the subsoil (sand, gravel, etc.) which forms the well floor, without disturbing the arrangement of the finest particles forming the flooring.

The velocity at which this disturbance commences is known as the "critical velocity" and this varies with different qualities of subsoil. For instance in a well sunk in gravel, the water passes through this material at a comparatively high velocity before the smallest pebbles are displaced, whereas, in a well sunk in sand, the critical velocity is much lower, the finest particles of that material being more readily displaced than small pebbles.

Water may be withdrawn from any well for an indefinite period without damage to the well, provided the critical velocity is not exceeded, but, if the rate of withdrawal of the water exceeds the critical velocity, the effect is as follows: the finest particles of sand at, and near the surface of the floor of the well are the first to be displaced, these will be in partial or full suspension, according to the velocity of the water; fine particles from the layer below the surface will travel upwards to replace the voids left by the particles from the surface layer, and these in turn will be carried into the well. This action extends below the

level of the bottom of the walls or curb of the well and also extends laterally; the fine particles flow in from under the walls, the density of the subsoil is being altered, the spaces between the particles of sand increased.

The disturbance of the subsoil is within a roughly shaped plano-convex figure, on the plane surface of which the well rests, and the superficial area of the whole figure (excluding the well area) is such, that the water passes through this surface at the critical velocity for the subsoil.

What then is the result of exceeding the critical velocity of a well? (*a*) The finest material is washed into the well and forms a new floor in the well above the level of the old floor, *i.e.*, silting occurs. (*b*) The subsoil under the well is loosened and the well tends to sink and is liable to collapse.

The principle of exceeding the critical velocity in wells is adopted for sinking wells for foundation work, powerful pumps being used to pump out the sand, gravel, etc., which flow into the well, thus loosening the foundation, into which the well sinks by gravity.

Various expedients have been tried in order to increase the yield of wells beyond their critical velocities, one of these is to fill in the floor of the well to a certain depth with gravel of various sizes, arranged somewhat in the manner of a percolation filter, but in reverse order, this has not proved satisfactory as after a short time the wells again become silted, by sand etc., being carried up through the interstices of the stones. Exactly the same feature is observed in ordinary water filters when worked too rapidly. Where sand of varying grades of coarseness forms the floor surface of wells it has been found that the fine particles are disturbed at velocities of $2\frac{1}{2}$ feet to 3 feet per hour, *i.e.*, the critical velocity.

Another method is to cover the floor of the well with a fine straining material, and this also has proved unsatisfactory on account of the finest particles of the subsoil being washed through the strainer and silting on its upper surface, while at the same time the coarser particles pack on the under side of the strainer

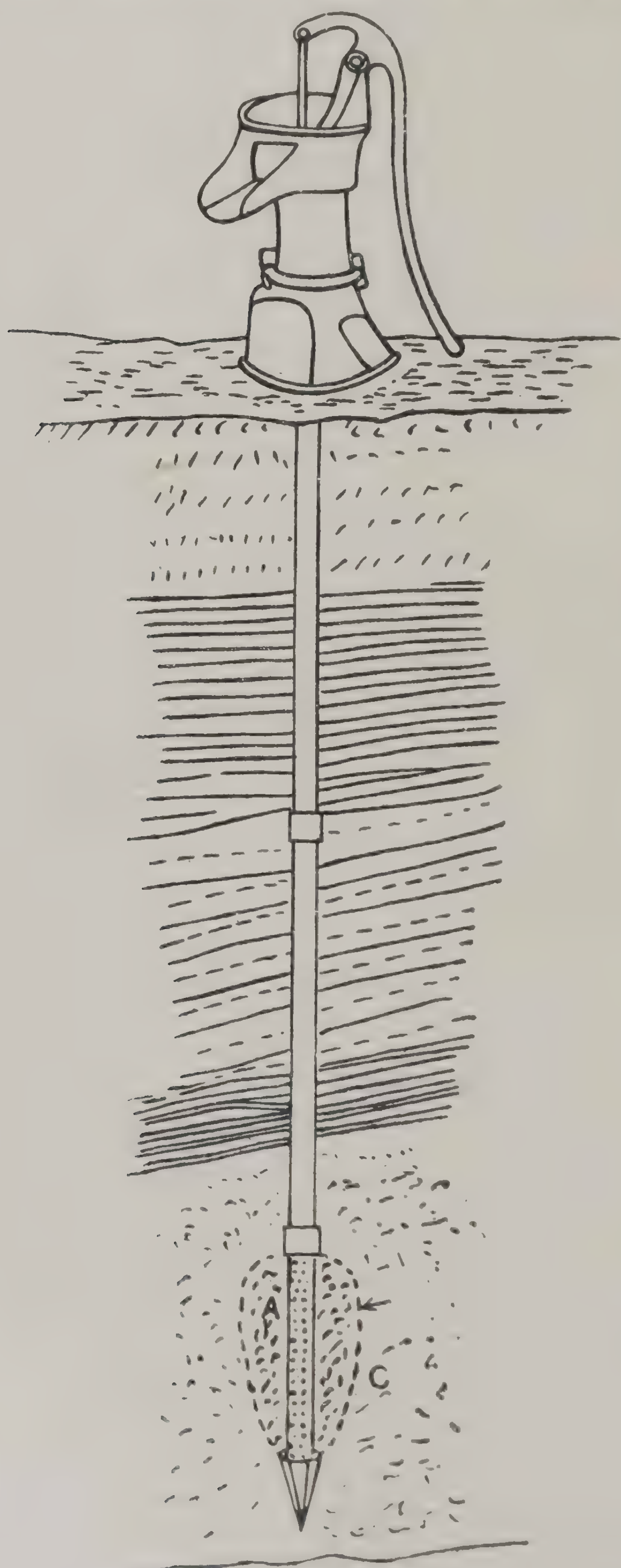
thereby reducing the flow until the yield ultimately falls again to the critical velocity.

Experiments on the yield of ordinary wells have been carried out for over 30 years by various engineers in many parts of the world, and the conclusions drawn from these are, that it is unsafe to withdraw water for any length of time, at a rate exceeding the critical velocity of the subsoil of the well. The critical velocity in sand of varying degrees of fineness has been found to be between $2\frac{1}{2}$ and 3 feet per hour, and even in coarse sand of fairly uniform grain, only a very slight increase in this critical velocity has been observed. The critical velocity in various qualities of sand being within comparatively narrow limits and loading and screening of the floors of the wells having little effect on their velocity; the question arose, why is it possible to extract a much larger quantity of water per unit time, area, from the Abyssinian and American forms of tube wells, than from ordinary wells in the same subsoil.

The writer has been investigating this subject for twelve years, and experiments carried out with tube wells of various forms in several conditions of subsoil, natural and artificial, have resulted in the conclusion that water may be withdrawn constantly from these tubes at a rate which represents a velocity through the water way area of the strainer of forty to sixty times the critical velocity of the subsoil. That is to say, if an ordinary well with floor area of one unit discharges one unit of water per minute under a head of six feet without exceeding its critical velocity, or say half a unit of water per minute when under a head of four feet, then a tube well in the same soil and having a straining waterway area of one unit, will deliver, when under the same head of six feet, from forty to sixty units of water per minute, or from twenty to thirty units per minute when under a head of four feet.

For purposes of illustrating the reasons for this, the Abyssinian tube well may be taken. This consists of about 20 feet of pipe say $1\frac{1}{2}$ inches diameter; one end of this pipe is perforated, for a length of a few feet, with a number of small

holes about 3/8 inch diameter; over this perforated portion of pipe a straining material, usually fine wire gauze, is secured.



Abyssinian Tube Well.

A—"cavity" consisting of coarse particles of sand surrounded by C—unaltered sand.

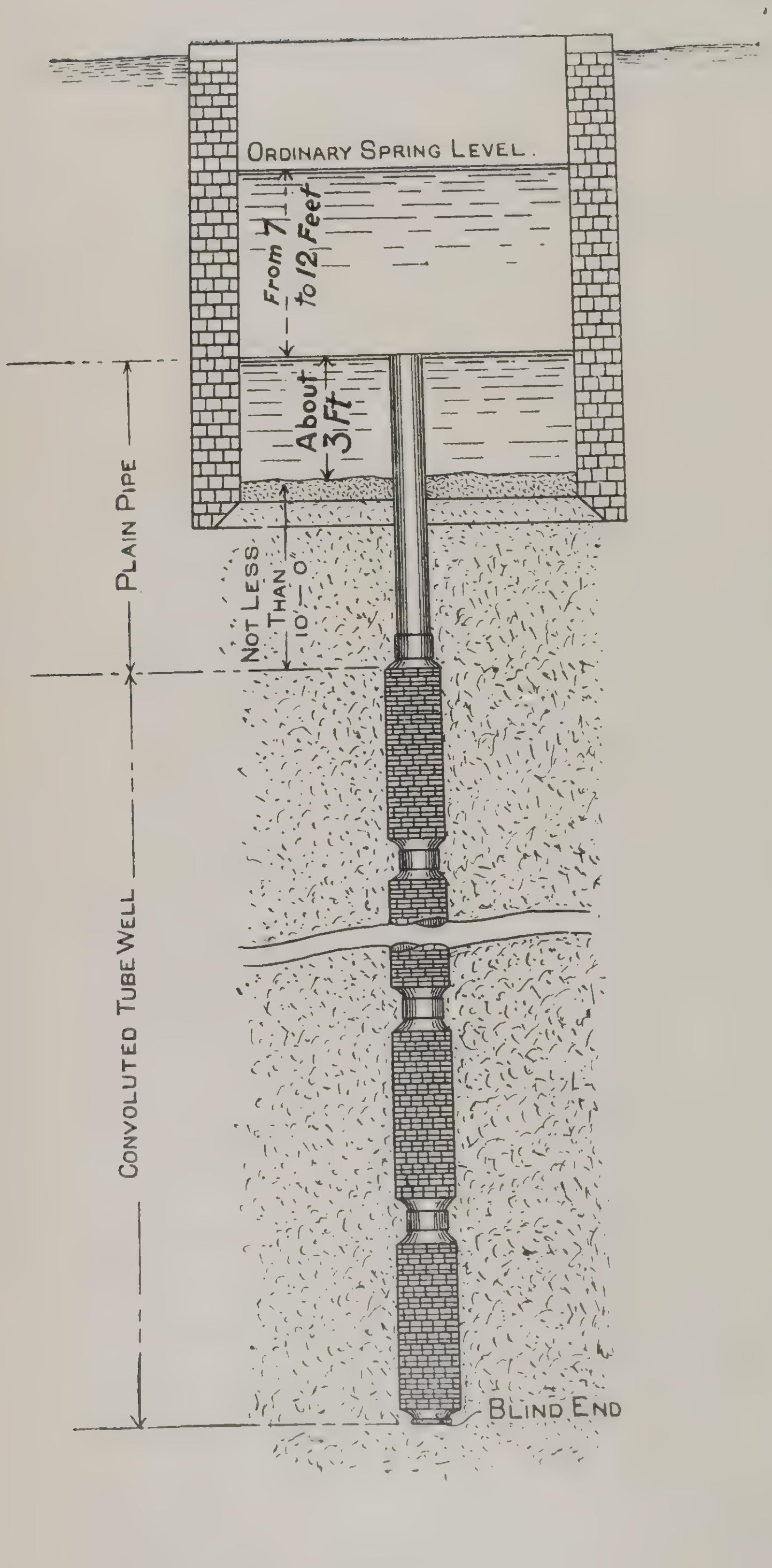
and over the gauze, in order to protect it from damage, a piece of perforated sheet metal is secured. The perforated end of the

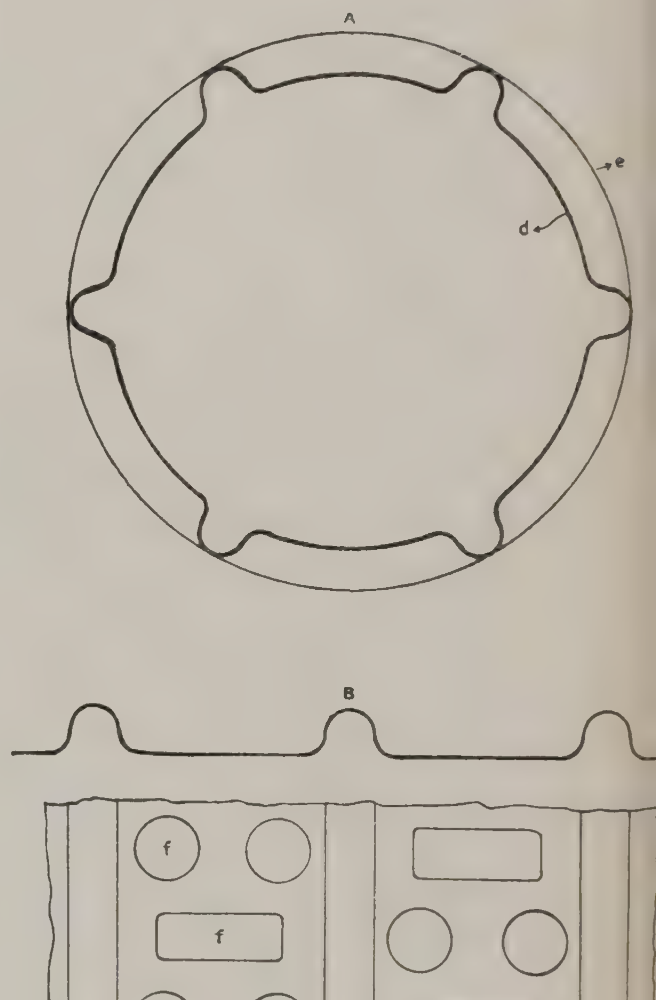
pipe is closed, and provided with a metal point for driving into the ground. The whole length of tube is driven vertically into the ground, leaving only one foot or so above ground level: a hand pump is attached to the portion of pipe projecting above ground. This form of tube is of course only suitable for low lifts, *i.e.*, when the water level is about eighteen feet from the ground surface.

On working the pump, a mixture of sand and water is discharged and pumping is continued until the water comes away free from sand, and thereafter a constant supply of clear water may be obtained.

Now what has happened round the strainer or perforated portion of the tube is that the fine particles of sand have been washed through the straining material into the tube, and the tube being of small bore in comparison to the quantity of water passing through it, the velocity up the tube to the pump is sufficient to carry the sand with it, keeping the inside of the tube and strainer free from silting. The subsoil surrounding the strainer portion of the tube has become freed of its finer particles, and therefore has a higher porosity than the undisturbed subsoil; this freeing of the subsoil surrounding the strainer takes place within a pear shaped figure, the strainer tube being the axis; the surface area of the figure is such that the water passing through this surface has a velocity not exceeding the critical velocity for the subsoil. Therefore surrounding the strainer we have what is usually called the "cavity" which is only a cavity in the sense that it is freed from the smaller particles of sand and contains the coarser material loosely packed. The writer's experiments have shown that this coarse material arranges itself around the strainer according to size of grain, the largest being next to the strainer, then the second largest and so on to what might be called the critical velocity limit, where the disturbed merges into the undisturbed subsoil.

These Abyssinian tube wells give comparatively small discharges and owing to their construction do not last any great





A.—Cross section of convoluted tube well; (*d*) body of tu
(*e*) straining material.

B.—Piece of convoluted sheet before forming into tube;
perforations in sheet.

length of time, but are extremely useful for domestic supplies and are inexpensive to repair. The fact that the straining material is in contact with the perforated portion of the tube, reduces the waterway area of these perforations by the amount of wire in contact with the perforations, this represents quite three-fourths of the area thus rendered ineffective.

The convoluted tube well which is designed for large discharges, differs from the many forms of tube wells on the market in so much that it is the only tube well which has the waterway area of the straining material equal to the waterway area of the perforations. The tubes are made from sheet steel, specially shaped to obtain this result, which prevents any change of velocity between the straining material and the body of the tube and thereby reduces friction and loss of head to a minimum.

The straining material is composed of heavy copper wires lying parallel, and woven with copper ribbons ; this arrangement forms a substantial and lasting material combined with a maximum of fine slots for the percolation of water.

Convoluted tube wells are manufactured in various sizes for discharges ranging from 5,000 to 45,000 gallons per hour.

The method of sinking and working these tube wells is as follows :—If the tube is required to augment the supply of water to an existing well and the desired quantity of water from the tube well has been decided upon, a tube well estimated to yield the nearest quantity above the required amount should be selected. Now assume that the tube selected is 40 feet in length, then a bore tube of a few inches larger diameter than the diameter of the tube well should be sunk in the well to a depth of not less than 50 feet below the bottom of the well. The tube well is lowered into the bore tube, and sufficient plain pipe is added to the tube well, to bring the upper end of the plain pipe not less than seven feet below the normal spring level in the well ; the bore tube may now be withdrawn and the tube well is ready for use. So long as the water in the well is not lowered more than would exceed the critical velocity for the material forming the well floor, there is no need to cement or otherwise seal the well floor,

the tube well will yield its supply in addition to the yield of the well.

In cases where the yield of the well is small, due to a small well, to the floor of the well being in a bad water-bearing stratum, or to other causes, it is advisable to seal the well floor with cement concrete, the water level in the well may then, if desired, be reduced below that level which would represent the critical velocity for the material forming the well floor, but, this lowering should not be carried to excess, or in other words, very little more water than the amount the tube is designed to discharge should ever be pumped from these tube wells. Overpumping causes the coarse particles which are too large to pass through the straining material, to pack against the strainer thereby reducing the porosity of the material surrounding the strainer and the discharge from the tube well is consequently reduced.

Convoluted tube wells may be sunk direct into the ground and worked by attaching the pump to the upper end of the plain tube, the plain tube then becomes the suction pipe of the pump ; this arrangement is particularly convenient where spring level is within the suction action of pumps worked on ground level. Considerable care should be exercised in fixing the pump level relatively to water level as various forms of pumps differ very considerably in efficiency on different suction lifts ; generally the suction should be as short as possible.

In situations where the spring level is at a depth below ground surface too great for the suction action of a pump worked on ground surface, the pump may be placed in a chamber below ground level and within convenient suction distance of the reduced water level. For this reason it is often convenient to sink these tube wells in old wells, which provide space for the pumps or the small tubes may then be worked by Persian wheels or chain pumps.

Where the water level is very considerably below ground level, the Ashley tube well pump should be employed, and in order to obtain the full discharge of the tube well the plain tube should be of larger diameter than the straining tube.

The Ashley pump can be worked with safety in this tube to depths of several hundreds of feet below ground surface. In single pumping plants of this type, a water compensating balance relieves the weight of the pump rods; in the duplex sets, the rods of one set are balanced by the rods of the other set.

Tube wells which are worked by the Ashley pump should be carefully shrouded to prevent powdery sand from reaching the valves; shrouding is an advantage also in very fine sand or other low porosity subsoil.

Convoluted tube wells are manufactured for India by the Empire Engineering Company, Cawnpore, and are stocked with a standard gauge of straining material which is suitable for most places, but, it is advantageous to submit geological sections and samples of the strata met with, in order to obtain the tube best fitted to the conditions under which it has to work.

The smallest stock size of convoluted tube well, 3½ inches diameter, will generally be found sufficient for increasing the water supply in wells in which Persian Wheels, or other forms of animal power water lifts are employed. These tubes are capable of delivering up to 5,000 gallons per hour, cost Rs. 272, and can be sunk and made ready for use for a further expenditure of roughly Rs. 200/-, or under Rs. 500/- in all. This sum is approximately one-eighth of the cost of ordinary wells of equal capacity, and in the larger sizes the difference between the cost of tube wells and wells of equal capacity, is much more marked.

Well Irrigation in India has varied little in the past and this is no doubt largely due to the limited supply of water which can be drawn from any one well. From observation made of over 40 wells in the Punjab, I have found that with one pair of bullocks working ten to twelve hours per day, the quantity of water lifted is 2,000 gallons per hour on 30 feet lift, and 2,500 gallons per hour on 25 feet lift. With improved chain pumps 2,400 gallons per hour can be lifted 30 feet by a pair of bullocks, and the rate for these with an attendant averages Re 1/ per day.

The cost of a chain pump or Persian Wheel and bullock gear suitable for this work is roughly Rs. 300, a well as built by zemindars may be taken at Rs. 1,000/- the total cost of the plant being therefore Rs. 1,300.

The annual maintenance is as follows :—

Interest on Rs. 1,300 at 4 %	Rs.	52/-
Depreciation of well only at 5 %	"	50/-
Depreciation of Persian Wheel at 10 %	"	30/-
Pumping cost, bullocks at 1/- for 365 days	"	365/-
Total annual cost =	"	497/-

say Rs. 41/6/- per month.

The quantity of water pumped per month is 2,400 gallons × 12 hours × 30 days = 864,000 gallons at a cost of Rs. 41/6/- or 1,305 *gallons for one anna.*

To put down steam or oil plant to pump such a small quantity of water would not be economical, but if a few zemindars combined and put down a medium sized tube well capable of yielding say 25,000 gallons per hour for a lift of 30 feet the cost would work out as follows :—

Water Horse Power, $\frac{417 \text{ gallons per minute} \times 10\text{lbs.} \times 30 \text{ feet}}{33{,}000} = 3{\cdot}8$

Efficiency taken at 0·45, the H.P. required = 8·4

and the nearest size of engine is 9 B. H. P.

Oil consumption at 0·85 pint per B. H. P. per hour would amount to $\frac{0{\cdot}85 \times 9 \times 12}{8} = 11{\cdot}475$ gallons, and the cost of 125° kerosine oil for most places in the Punjab does not exceed 9½ annas per gallon.

The daily driving cost is therefore—

	Rs.	A.	P.
Oil consumption 11·475 gallons at 9½ annas per gallon ...	6	13	1
Lubricating oil 1 pint at Rs. 2 per gallon	0	4	0
Starting oil ½ pint at 9½ annas per gallon	0	1	3
Waste and sundries	0	1	8
Driver at Rs. 30 per month	1	0	0
Total daily driving cost ...	8	4	0

Cost of Works.

	Rs.
Tube well sunk complete	1,600
Oil engine and pump	3,000
Engine house, driver's quarters and godown	1,000
Allow for sundry requirements	400
Total cost of works ...	6,000

Annual Maintenance.

	Rs.
Interest on Rs. 6,000 at 4 per cent.	240
Depreciation of tube well and engine at 10%	460
Depreciation of engine house, etc., at 5 per cent.	70
Daily driving cost at 8/4 × 365	3,011
	3,781

say Rs. 3,800 per annum.

Therefore the quantity of water which can be pumped for one anna is 1,800 gallons or an increase of practically 40 per cent.

If the plant is put down in duplicate to allow for stoppages for petty repairs, etc., the annual maintenance would then be Rs. 4,550 or 1,500 gallons per anna, but with duplicate plant installed the engine could be run for longer periods by an additional driver, interest and depreciation would remain as before and a further reduction in cost effected.

This estimate of cost of pumping is higher than the actual cost would be, as it covers allowances for wastage, etc. The writer has three installations at work and is shortly putting down a fourth of 40 B. H. P. These installations are of 6½, 9 and 32 Brake Horse Power, and are all worked on a less rate than estimated above.

It is essential to select the pump and engine best suited to the particular work it has to do, otherwise a considerable drop in efficiency and consequent increase of working cost will result.

When the larger sizes of tube wells are employed, engines consuming crude oil may be employed ; this will cause a further saving of 20 per cent.

There is not the slightest doubt that by the use of tube wells worked with properly selected pumps and oil engines, lift irrigation can be effected at a rate very considerably cheaper than by any other method at present in use in this country.

There are already many convoluted tube wells working in the Punjab both for public water supplies and for irrigation purposes. One case in particular is worth mentioning. A well of ten feet diameter was sunk over thirty years ago, with the intention of installing a Persian Wheel for irrigation purposes; unfortunately the subsoil was a mixture of running sand and clay; a single bullock Persian Wheel dried the well in half an hour and recuperation took so long that the Persian Wheel was dismantled and the well abandoned after a sum of over Rs. 2,500 had been spent on it. The writer installed a $3\frac{1}{2}$ inch convoluted tube well and now 100 gallons per minute or 6,000 gallons per hour is being drawn from the well for irrigation purposes.

EXPLANATION OF THE DIAGRAM.

No. of plot (each measuring ½ acre).	MANURE APPLIED.		
	1909.	1910.	1911.
1	Castor meal, 15 maunds per acre.	Castor meal, 4 maunds per acre. Nitrate of potash, 40 lbs. per acre. Superphosphate, 120 lbs. per acre.	Castor meal, 4 maunds per acre. Nitrate of potash, 40 lbs. per acre. Superphosphate, concentrated, 60 lbs. per acre. Sulphate of ammonia, 120 lbs. per acre.
2	Green manure only, not dug in, only sickled when mature.	Green manure only ...	Green manure only.
3	Castor meal, 7½ maunds per acre.	Nitrate of potash, 40 lbs. per acre. Superphosphate, 120 lbs. per acre.	Animal meal, 2 maunds per acre.
4	Nothing (check plot) ...	Nothing (check plot) ...	Nothing (check plot).

EXPERIMENTS IN MANURING ON A TEA ESTATE IN DARJEELING.

BY

CLAUD BALD,

Manager, Tukvar Co., Ld., Darjeeling.

It is impossible on a hill garden to find a continuous block of land where the quality of the soil is exactly equal over any considerable area, as the undulations of the land of necessity divert some of the best constituents of the soil into the hollows from the ridges, more or less, during heavy rain.

The block which was selected for these experiments seemed to all appearance as nearly equal in quality throughout as it was possible to obtain; and yet the event proved that there was some difference in favour of one side. The land was carefully measured, and the straight lines of tea bushes made it easy to plot off accurately four plots, each measuring half an acre. They were numbered from one to four. The land is slightly better in the direction of No. 4, which has been kept as the check plot. In regard to cultivation, pruning and plucking, all the plots have been treated exactly alike; so that the experiments might determine the results of the manuring only. The experiments were continued for three years. The diagram opposite and its explanation indicate the treatment and the resulting crop of tea for each year. The cost of manuring is shown on page 160. It will be noted that no farmyard manure has been experimented with; the reason being that on the estate no grazing is permitted, and there are very few animals kept, hence natural manure is not available in any considerable quantity, and it has become necessary to consider whether chemical or artificial manures can be applied in such a way as to prove remunerative.

In the first year the object was to find out whether the application of *castor meal* would give any encouraging result. An exceptionally heavy dressing was given to plot No. 1, while half the quantity was given to No. 3, and No. 2 was treated with *green manure* only. The green manure was a crop of *dal* similar to what is known as "*Mati Kalai.*" The crop for the year was largest from No. 4, the untreated plot, indicating that the castor meal had practically no effect upon the outturn, while the better soil in the direction of No. 4 asserted itself.

In the second year Nos. 1 and 3 were treated with *chemical* manure, but *without nitrogen*, except the small quantity contained in the castor meal on No. 1. The nitrogen was purposely omitted, as it was feared that this manure would tend to the production of rank leaf, making coarse tea. No. 4 was again almost the highest in quantity of produce; but it was beaten by No. 2, which had been treated for two years in succession with green manure only.

In the third year No. 1 was treated with a *complete chemical* manure, with the addition of a small dressing of castor meal. No. 2 again had *green* manure only; while No. 3 had an application of *animal meal.* The nitrogen applied to No. 1 (in the form of ammonia), sent up the crop from that plot to the highest point; but it was closely followed by No. 2, which made an increase on its previous record. The check plot made rather less tea than in the previous year.

Some of the outstanding facts in connection with these experiments are the high cost of chemical and artificial manures in a remote district like Darjeeling, and the extreme doubtfulness of their economic utility; also the possibility of using expensive manures while accomplishing practically no result, in consequence of the manure used not being of a suitable composition: then there is the special outstanding fact that while green manuring is the cheapest method, it produces remarkably satisfactory results. It may be noted that the manures were used in one application only, as the nature of the ground was such that it was not advisable to dig at all during the rainy season, for fear of losing soil by wash.

An important fact in connection with the green manuring is that the crop was not dug into the land in the green state. It was only sickled when it came to maturity, and left as a mulch upon the ground until the rains were over, when the rotting stuff was dug in. At the same time a similar quantity of ordinary jungle growth was dug into each of the other plots. It is probable that the rotting leguminous crop contained a larger proportion of nitrogen than the rotting jungle; but in any case it seems that the special benefit which accrued to plot No. 2 may be chiefly attributed to bacterial action on the roots of the leguminous crop.

The relative amount of crop having been determined as a result of the manuring, it remained to be seen whether there was any difference in the quality of the teas produced under the different circumstances. This is indeed the most important consideration of all on a hill garden, where the quality of the teas must of necessity be the first consideration. With a view to determining this a set of samples was carefully prepared from each plot, and reported upon by an expert. The valuations were $10\frac{1}{2}d.$, $11d.$, $9d.$ and $1s.$ per lb. of samples made from plots 1—4 respectively on 18th September 1911. It has been felt, however, that in order to determine the real relative value it is necessary to have a series of samples drawn from the plots at stated intervals throughout the manufacturing season, as it is well known that some of the chemicals are so evanescent that their effects upon the teas may be very great in the earlier part of the season, while other ingredients which only become absorbed by the plant after some months may have a very different effect upon quality towards the end of the season.

A digest of the results for the three years in crop and cost is as follows:—

	1909.	1910.	1911.	TOTAL.
Tea per acre in	lbs.	lbs.	lbs.	lbs.
Plot No. 1 ...	247	265	345	857
,, No. 2 ...	239	313	324	876
,, No. 3 ...	258	270	312	840
,, No. 4 ...	275	305	286	867

The cost of treatment works out as follows :—

	1909.	1910.	1911.	TOTAL.
Plot No. 1 ...	Rs. 64 0 0	Rs. 33 6 0	Rs. 44 9 6	Rs. 141 15 6
,, No. 2 ...	,, 4 9 0	,, 4 9 0	,, 4 9 0	,, 13 11 0
,, No. 3 ..	,, 32 0 0	,, 16 6 0	,, 15 14 0	,, 64 4 0
,, No. 4 Check Plot; no expenditure.				

The total crop from No. 4 is comparatively high, because it stood relatively so high in the first year. Apart from the question of the relative quality of the teas produced, it will be seen that the extra crop from No. 3 is not sufficient to pay for the treatment which was given to it, while the cost of treatment to No. 1 is altogether prohibitive.

The valuation of the samples places No. 4, the untreated plot, much higher than any of the others, while the green manured plot comes second, and the plot treated with animal manure is given a very low place. It may be remarked again, however, that the valuations, for the reason above mentioned cannot be regarded as final.

WAYS AND MEANS OF INDIAN AGRICULTURAL DEVELOPMENT.

BY

A. C. DOBBS, B.A.,

Assistant to the Agricultural Adviser to the Government of India.

Those who are engaged in attempting to improve Indian agriculture—to assist the Indian ryot to get a better living,—are constantly being confronted with the difficulties due to his immediate poverty and the low economic condition of the country generally. Capital in India is scarce and interest high, and while the prices of agricultural products are low, the paraphernalia necessary for any marked improvement of system are relatively expensive and their maintenance in good repair is a constant drain.

It must be admitted that as far as the low profits of agriculture in India are due to these causes, the efforts of the Agricultural Department can do little except assist in creating a market in India for implements and manures, and so effect some reduction in their cost. The main activities of the Department hitherto have been in this direction and in that of improving and standardising seeds and popularising the best existing methods of cultivation. But the limit of improvement in these directions is a definite one, and the Indian cultivator using the best implements and seed on the best system will not be very much better off than he is now unless his scope of usefulness can be extended so as to multiply the produce of his labour manifold.

The degree to which such extension would have to take place in order to place the Indian on a level with the European or American agriculturist, is perhaps best illustrated by

a comparison of the wages of the Agricultural labourer in these three countries; from which it appears that the Englishman is at least four times, and the American eight times as effective as the Indian labourer.

It is often carelessly assumed that this varying effectiveness is chiefly or even entirely due to racial and climatic differences and that little can, therefore, be done in any limited time to raise the effectiveness of Indian labour. But a little consideration will show that there is another factor which must have, quantitatively, a far greater effect on production than questions of race and climate: and that factor is the extent of the control of physical energy exercised by the labourer. The main sources of such energy are, the food of men and animals, wind, falling water, coal and oil: the history of civilisation, from the dynamic point of view, is the history of the progressive extension of man's control from that of the relatively small quantity of energy contained in the food he eats to that of the greater, but still not—per head of population—very much greater amount represented by the present consumption of the fodder of draught animals, of coal and oil and of the power derived from waterfalls and the wind. The labourer using his own strength only, however ingenious the implement with which he works, controls, though perhaps very efficiently, only the energy contained in the food he eats—represented approximately by the heat given out by the same amount of food if dried and burnt. The driver of a team of oxen or horses controls, in addition, the amount of energy contained in the food of his team; while the driver of a steam traction engine controls, even though with comparatively small efficiency, the relatively enormous amount of energy contained in the coal burnt. And the results of the labours of the communities typified by these men, and ultimately the rate of wages in each, will be correspondingly, though of course not proportionally, great. One could venture, for instance, to assert with some confidence that in different agricultural districts of India, the rate of wages would be found to vary generally with the size of the bullocks—or rather with the weight of the team—

customarily used for draught purposes, and there is no doubt that the American farmer can afford to pay his men a wage of a dollar a day mainly because of his efficient system of using horses.

This being so, the problem of increasing seriously the prosperity of the Indian ryot becomes one either of increasing the weight of his team of cattle, or of providing him with a more powerful agency for doing his work. Taking the question of cattle first, it is clear that the argument so often advanced against the introduction of new implements which, though essentially more efficient than those now in use, are also heavier to pull—the argument that they need a heavier team to pull them, is one that really tells in favour of the new introduction; for in addition to the increased efficiency of the implements, they enable the driver to find a use for greater cattle power, and so increase his productive capacity. It would almost always be possible for the owner of even a small holding so to increase the produce of his land by better cultivation or irrigation as to provide the additional amount of fodder for larger bullocks if he could not reduce their number. But in any case the smallness of existing holdings could nowhere prove a permanent bar to economic advance.

There can be no cavil then at the attempted introduction, in any district, of implements which only the heaviest bullocks available can draw—provided that the implements are efficient in themselves, their size is all to the good and will increase the demand for the larger bullocks required to draw them.

The use of large numbers of bullocks in one team, as in South Africa, is a question almost of a different order, requiring an accumulation of capital in the hands of enterprising and experienced farmers such as hardly exist in India; and probably also the stimulus of a scanty population. It may even be conceded to the pessimists that the preliminary training and management of large teams would require more doggedness than a race bred in the enervating climate of India could command.

We are brought then to the question of the possibility of substituting some more powerful agency for bullocks in Indian agriculture.

Among animals, experience seems to show that the horse is the best, being both stronger and more adaptable than the bullock, but the blood temperature of the horse (100°F.) is slightly lower than that of the bullock (101°-102°F) and, with the thermometer in the neighbourhood of blood heat, and a moist atmosphere, any such difference must make some difference in the cooling capacity and consequently in the efficiency of the two animals, because an animal becomes incapacitated if its temperature rises even a few degrees above the normal. It is, therefore, improbable that the horse, or any animal with a lower blood temperature than the bullock would prove an efficient substitute under Indian conditions.

This difficulty, of the approximation of the atmospheric temperature to that of the blood of animals under conditions that retard evaporation from the skin and consequent cooling, gives quite a special importance to the question of the use of mechanical means for controlling energy in tropical and subtropical climates. The efficiency of a steam or oil-engine is comparatively independent of atmospheric conditions, whereas that of an animal, depending absolutely on its capacity for immediately getting rid of the waste heat generated in the performance of its work, becomes rapidly less as the wet bulb thermometer rises.

It seems then that if the economic efficiency in agriculture of the inhabitants of India, and other countries where a considerable proportion of the work has to be done under conditions of excessive heat and moisture, is to be raised to anything like that of the inhabitant of the temperate zones, it must be by the substitution of mechanical for animal agencies for the bulk of the farm work. There is thus every reason to encourage the use of engines for such work as cultivation and transport, and the question of how they can be generally introduced into India is one of considerable interest.

The conditions favourable to the use of ploughing and traction engines are, firstly, large areas of open land, secondly, cheap fuel, and thirdly, capital. All these are already to be found in the Gangetic plain from the United Provinces to Assam, and

there should be every chance of success for any landowner in that region taking up the problem seriously, particularly in connection with the growing of sugarcane for which deep cultivation is profitable and the area of which is usually limited by the available labour supply.

But in many districts the occupation of numerous small areas of land by ryots is likely to prove a serious obstacle to the formation of the large spaces required for mechanical cultivation, and in such districts its introduction will have to be left to the comparatively slow operation of economic forces, assisted perhaps by the spread of the co-operative idea.

And it is interesting to consider how the present trend of the world's economics is likely to affect this question. We have during the last century experienced an enormous expansion of the amount of energy available for man's use. Immense areas of land have been opened up in America, Africa and Australia, providing both energy in the shape of supplies of fodder for an unprecedented proportion of draught animals for agricultural work, and a field for them to work in. At the same time mechanical science has come into being and immense reserves of fuel have supplied the energy for innumerable engines. The big waterfalls of the earth have also been harnessed for industrial purposes. Thus a new standard of living has been set up among the western nations ; everything, including energy itself and the means of controlling it, has become easier to get, the machinery of production—capital—has become commoner, and wages are rising all round.

Now although the end of the reserves and supplies of energy is not yet in sight, a large proportion of the face of the earth has already been exploited, while, comparatively, a small proportion of the population have as yet grasped the advantage of the greater scope thus offered. Only recently comparative freedom from universal financial and industrial crises has been guaranteed by the placing of the gold supply of the world on a broad industrial non-speculative basis, and with the growth of capital it seems probable that the European nations have now crossed the

threshold of an economic expansion which, in bringing the new standard of living within reach of all, will rapidly appropriate all the visible supplies of energy to their use. The world is in fact apparently now coming face to face with an appreciation of available energy limited only by its utility as measured by the results it will produce. Food, fodder and fuel are again becoming relatively more valuable and will be economised and eked out so as to produce the maximum possible result from the minimum expenditure of the only thing that is really ever expended—the value of which lies in its expenditure—energy. This must, in the absence of the discovery of sources of energy of a higher order of magnitude than those now known, produce a continual appreciation of energy—food, fodder and fuel—in terms of the products of its application. Owing to increasing economy the same quantity of energy will produce more and exchange for more of the durable things typified by gold ; coal mines, oil-wells, waterfalls, land, will continually rise in value.

But this economy will only be effected by more and more perfect and elaborate organisation ; energy will only be worth more because it is more intelligently and economically spent ; as the value of energy rises, so will the value of organisation and intelligence, the solitary worker with little capital will be worse off than before because he will have to pay more for the energy he requires and will produce relatively less than members of larger and more perfect organisations. The backward farmer will go to the wall as his assessment for rent or revenue rises, and the small holder will have every inducement to join a larger organisation either by co-operation or by selling his holding and getting employment from others.

Under such circumstances, it seems probable that bullocks will ultimately give way to engines everywhere in the cultivation of the plains of India and that the population will find a use for the larger amount of energy they will thus control in elaborating agricultural and forest products to a greater and ever greater degree. Cotton mills, oil mills, sugar and alcohol factories will grow up in the midst of the large spaces from which they will

draw their raw material and probably their fuel. If in the process the cow gives place to the goat or the sheep, and the ryots' fields dwindle to gardens, is not this prospect better than that of congestion in large cities and desertion of the countryside such as has been fostered in other countries by the concentration of the expenditure of energy in large towns? Thus if the dream that many love to indulge in—of the small holder in his separate allotment,—depends for its realisation on a perfection of the means of distribution of energy and its control in relatively small units, which will no doubt come in time, but is too remote to be of immediate practical concern in a country where fuel is so scarce and badly distributed as in India; yet in her fertile plains there seems to be a prospect of an industrialisation that does not imply congestion.

Meanwhile the immediate requirements are capital and the engineer; and those whose efforts are directed towards hastening the introduction into the field of Indian agriculture, of these indispensable items of equipment, have the satisfaction of feeling that they are going with the stream and not too far in advance of the main tide.

* * * * *

Since the above was written, the following note issued by the Bombay Government has appeared in the press:—

"For some time past the Agricultural Department has been investigating the question of introducing mechanical traction for ploughing and other operations of cultivation. The question is becoming more and more important owing to the growing scarcity of fodder, cattle and labour, besides hand-digging being an inefficient means of clearing the soil of weeds. The Bajac windlass plough, drawn by bullocks, has now been introduced, and there is a rapidly growing demand for its use, but progress is slow as it works at a rate of one-fourth acre per day, and, in view of the enormous areas of weed-infested lands that require deep ploughing, steam traction was absolutely necessary. A scheme was accordingly prepared and submitted to the committee of the

Sir Sassoon David Trust Fund, who provided funds for obtaining a double engine steam ploughing plant. It is expected that this plant will plough 8 acres per day, at a cost of rupees seventeen per acre, about half the cost of the Bajac plough. In sugarcane tracts the introduction of the steam plough promises excellent results as the soil requires deep cultivation during the dry season, an operation which under existing conditions puts the cultivator to great expense."

PLATE XXV.

ALPHONSE (BOMBAY).

KALA APOOS.

GOL APOOS.

THE ALPHONSE MANGO.

BY

S. H. PRAYAG, B.Ag.,

Bombay Agricultural Department.

The Alphonse (commonly called Apoos) mango is one of the most highly prized fruits of India. It has been called by some the "Prince of Mangoes." Mr. Woodrow in his book on Gardening in India mentions that it is universally admitted to be the finest of all varieties of mango. In the Journal of the Royal Horticultural Society, page 755, Vol. 26 (1901-02), Maries has made mention of the Alphonse mango and regards it as the most delicious fruit and a general favourite. Personally I prefer this to all other varieties, as it excels others in every respect, though to some the taste is not so agreeable as that of the Pairi.

Regarding the origin of the Alphonse, there appears to be still a doubt. Maries says that this variety originally came from Salem in Madras Presidency and is now generally grown in Bombay gardens. But its original home seems to be Goa as the name Apoos (a corruption of the Portuguese name Alphonso) indicates, whence it must have been spread by man.

Though it may be supposed to have come originally from Goa the Bombay Alphonse is inferior in every respect to the Goa Alphonse. The Bombay Alphonse is smaller in size and scarcely weighs more than 350 grammes, whereas the Goa Alphonse weighs from 375 grammes and upwards, and is more delicious. The Goa Alphonse has a left shoulder higher than the right and has a slightly perceptible beak, but the Bombay variety is almost entirely lacking in the beak. (See Plates XXV and XXVI.)

The Goa Alphonse has been said to be the true Alphonse. To what circumstances its superior merit is due, whether to any peculiarity in the soil or climate, is hardly possible to decide. But this excellence in fruits in favoured localities is not confined to the mango. It is found in connection with most fruits in many parts of India.

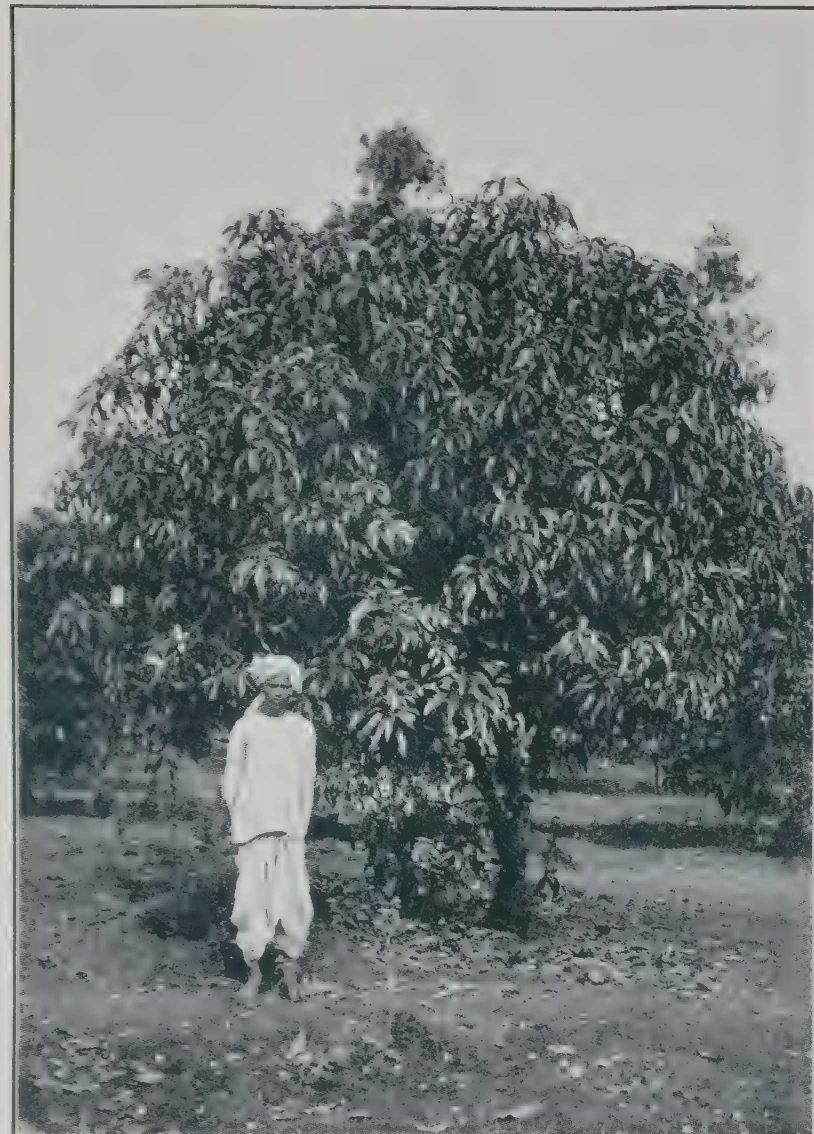
The skin of the Goa Alphonse is greenish yellow with reddish orange on the exposed shoulder. In measurements it is $9 \times 6 \times 4{\cdot}5$ cm. in the sample that I took. Though to some the taste is not superior to that of Pairi, its value is greatly enhanced by its keeping quality. A true Alphonse can be preserved for at least a fortnight after it is ripe and hence can be safely sent to foreign countries when it is unripe but fully developed in size. Its cultivation is now extending as it finds a ready market in many places. We find this variety the most frequent in almost every private gentleman's garden.

In the Bombay market, the bigger sorts of true Alphonse varieties of Goa are occasionally found, but these are sold very dear, sometimes as extra special quality. In favourable seasons they are sold from Rs. 2-8 to Rs. 3 a dozen; whereas in 1912 they were sold at Rs. 6 a dozen. In some parts of Goa, they are sold at the rate of 11 to 14 rupees a hundred, whereas in favourable seasons they are sold at Rs. 6 to 9 per 100. The price, however, fluctuates, according to the markets and according to the seasons of the year.

Many of the Mankurad varieties of mangoes found in Goa, are sold in Bombay as Alphonse. This is a variety nearly allied to Alphonse and closely resembles it in all respects except in size. It is a smaller fruit like the Bombay Alphonse. (See Plate XXVII.)

Sub-varieties.—There are three sub-varieties of Alphonse, *viz.*, Gol, Kala and Kagdi Apoos.

Since I could not get the Kagdi Apoos I shall describe here the other two varieties. Kala Apoos:—The fruit has the flavour of Apoos. A few months old bark of this tree is dark in colour. The leaves are also dark green in colour. Owing to



ALPHONSE MANGO TREE.

LEAF OF THE ALPHONSE MANGO TREE.

these peculiarities, it is named Kala Apoos. The beak is prominent in this variety.

Gol Apoos :—It resembles Alphonse in all respects except the shape which is round more or less and hence the name Gol Apoos.

Characteristics of the tree and leaf.—The leaves of the Alphonse vary very much in size. In a good Alphonse tree, the leaves are dark green, with a white midrib. Mr. Woodrow mentions that among the choice varieties, the leaves of Alphonse may be known by the bright red midrib apparent until the leaves are nearly ripe, but I have rarely seen this.

In a collection of trees, it is extremely difficult to distinguish the Alphonse trees by the leaves and the nature of the tree only.

The smell of the leaves has been considered by some as one of the distinguishing features of identification, but this too sometimes fails. The tree is rather stunted and rarely approaches graceful symmetry. The tree is not very hardy.

The tree shown opposite is nearly seven years old. The above description applies to the Bombay Alphonse, whereas the Goa Alphonse trees are free growing and of monstrous size, attaining the height of 60 to 80 feet and even more and bearing profusely sometimes as many as ten thousand fruits, thus proving what a tree can be like, when situated in favourable localities both as regards soil and climate.

MANGO CULTURE IN GOA.

BY

S. H. PRAYAG, B.Ag.,

Bombay Agricultural Department.

Of all the edible fruits that are found in the Bombay Presidency, the mango ranks as one of the best and sweetest. In point of taste and colour, there hardly seems to be any fruit that can excel it. It seems, therefore, no exaggeration to say that it is the choicest fruit of India. It has been alluded to by Lady Brassey as the "King of Fruits." Its culture in Goa, the reputed home of the grafted mango, cannot fail to be of interest.

The distinction that Goa has acquired as a mango centre is due principally to the large number of excellent varieties grown there. There are few parts of the Bombay Presidency where the mango grows to such perfection, where it enters more widely into commerce and where the whole industry has thriven more and has contributed to the welfare of a greater number of people than in Goa. It is the heart of this industry. The plantations are located near the creeks and sometimes extend into the fertile plains and up the slopes of the hills. Here the climate is hot and moist, and as a steamy climate is congenial to the growth of mango trees; they have been found to grow to perfection, bearing a luxuriant crop.

Soils.—In Shivoli, Kanyasu, Parsem, Mapuca and Thorla Goa the mangoes are found to grow on two kinds of soil, *viz.*, sandy and red laterite soil. Intermediate stages of these soils are also found to grow mangoes; but the best mangoes are grown in laterite soils and the soil that is not so very useful for the coconut, is reserved for mangoes.

Cultivation.—There is no regular cultivation followed anywhere in Goa, but huge trees are found to grow indiscriminately mixed with coconut, which forms the principal crop. The mangoes are grown from seeds and when they attain the age of 4 to 6 years they are grafted by the side method of grafting, which I shall describe here :—

At first a transverse cut $1\frac{1}{2}''$ to $2''$ in length is made in the stock at a distance of $9''$ to $1'$ from the ground. Above this a triangular notch $2''$ to $3''$ in length is cut out. The chief object

Fig. 1.—Method of side grafting, showing the triangular cut and the insertion of scion.

of cutting this notch is to stop a small portion of the ascending sap, in order that it may be absorbed by the scion. When a triangular cut is thus obtained, a longitudinal incision in the middle of the horizontal cut is made and is carried downwards very carefully up to the length of $4''$ to $6''$ according to the strength of stock and scion. The bark is then loosened for making way for the scion of the desirable variety. This is generally done by means of a small piece of hard wood cut in the form of the scion, as the instrument is frequently insufficient

for raising the bark. Care is taken not to bruise the inside wood. The scion is then inserted in the opening made for it and is gently pushed down till its shoulder rests on the top of the stock (Fig. 1). Further treatment is just the same as for other kinds of grafting. After two or three months when the graft has taken, the earth is heaped over the grafted portion, the head of the stock is topped off and only the scion is allowed to be seen. Watering is given every alternate day, if there be no rain and is continued for about 6 to 8 months, till the graft becomes sufficiently established.

Its advantages.—This method of grafting has advantages in the following respects :—

(1) It can be used to improve country mango plants growing in fields.

(2) Since the graft can be made upon a well-established country stock, the root system of which is well developed, the resulting grafted plant grows to a great size and bears profusely, besides lasting for a good number of years.

(3) Two or three or even five scions can be placed on one stock, so that if one does not succeed the others may thrive.

(4) It can be used on stocks up to 3½ to 4 feet in thickness provided the bark does not split.

(5) Two or three scions of different varieties can be inserted, so that we can get two or three good varieties on one plant.

(6) If the graft does not take, the original tree does not suffer in any way.

(7) The percentage of success by this method has been said to be greater than by others.

Conditions necessary for ensuring success :—

(1) The operator must use stocks which are in the condition of flush, *i.e.*, with the sap flowing freely.

(2) He must choose fresh and one year old scions with terminal buds just swelling. The scions should not be shrivelled and all unions made should be well fitting.

To ascertain the right condition of the sap in the stock a slit is made in the bark of the stock, at some little distance

above the point where the graft is to be placed and observation made if it separates very easily from the wood. If it will not separate, the operation may be postponed.

(3) When separating the bark from the stock no injury should be done to the inside wood. It should never be bruised.

(4) The stock should not be topped until the graft is finally established.

Manuring.—Systematic manuring of the mango is not practised. The only manure that is in common use is salt. This is applied at the rate of one basketful per tree, when the tree attains the age of 3 to 5 years. It is then used once in 3 years and is applied on the surface before the rains, just near the trunks of trees.

Diseases.—It is subject to all the diseases that are found in Poona. Loranthus abounds on the trees and no care is taken to remove it. "Black stem" (*Rhinocladium corticolum*), *Cephaleuros virescens* and "sooty-mould" (*Capnodium* sp.) are found. Removal of old decaying branches is not done at all and the trees are left to the tender mercies of nature. Even with all this struggle against diseases, it is surprising to note that the trees are very prolific bearers and fetch a considerable price.

Varieties.—The numerous varieties that are found here vary in quality, flavour, juiciness, and succulence of the pulp, size and shape of the fruit, etc. Some have a very pleasant and piquant taste, while others are delicious with a slight turpentiny flavour and stringiness. The quality largely depends on the proportionate size of the stone to the amount of pulp, on the absence of fibre and on the taste and lasting quality of the fruit.

For convenience sake I shall describe here only four select varieties, dealing with others in a separate paper. These are—

Goa Apoos, Mankurad, Fernandin and Maldez.

Size and weights are averaged from two typical fruits in each case.

Goa Apoos.—Weight 385 grammes; size $10{\cdot}9 \times 8{\cdot}5 \times 6{\cdot}5$ cms. General appearance—greenish yellow with small glands on the surface, beak very scarcely perceptible; left shoulder

higher than the right. Pulp and taste—yellowish, very sweet and piquant; no fibre—an excellent and much appreciated fruit. (Fig. 2, Plate XXVII.)

Mankurad:—Weight 226 grammes; size 8·6 × 6·5 × 5·2 cms. General appearance—left shoulder very slightly higher than the right; thin skin firmly attached to the flesh; beak absent. Pulp and taste—yellowish, very luscious; no fibres. (Fig. 3, Plate XXVII.)

Fernandin:—Weight 334 grammes; size 10·2 × 6·5 × 5·2 cms. General appearance—fruit longer than broad; small glands present; surface rough and warty; slight prominence below left shoulder, bright red on exposed side and yellowish-green on the non-exposed side; thick skin closely attached to flesh. Pulp and taste—bright yellow, thick, very luscious, a very superior sort. (See Plate XXVII.)

Maldez (Pokal):—Weight 256 grammes; size 10·7 × 6 × 5·2 cms. General appearance—greenish yellow, tinged with bright red on exposed shoulder; very slightly inverted beak.

Pulp and taste—orange red, sweet, distinct and agreeable flavour, slightly fibrous. (See Plate XXVII.)

Methods of disposal and marketing of fruits:—The grower sells his fruits usually through a broker. The broker acts as an agent for both the parties. It is sold by the grove as a whole for the season, the purchaser taking all the fruits, or each picking is sold separately by 'hundreds,' a 'hundred' meaning 130 in some parts of Panjim Taluka, whereas in Mapuca Taluka it means 105. In some regions of Mapuca Taluka where the mangoes are finer in grade and better for export owing to steamer communication, they are sold by true hundreds. Mango-growing for the market is a very profitable undertaking in some parts of Goa where they are grown as an industry. A considerable number of Apoos and Mankurad varieties are sent to Bombay markets through a broker—Maldez, Fernandin, Mankurad and Collace varieties are sent to the markets of Belgaum, Dharwar and Hubli, when steamer communication to Bombay is stopped.

PLATE XXVII.

Scale centimetres.

FIG. 2.

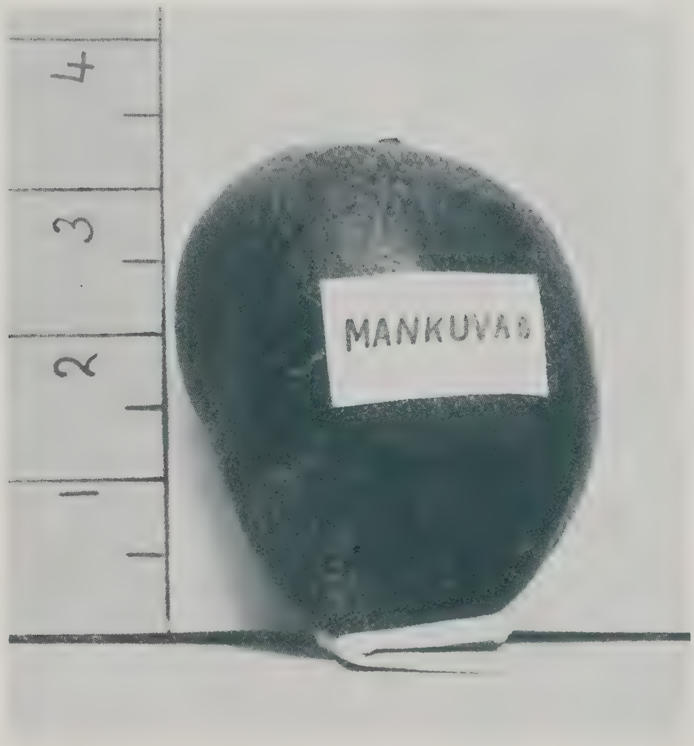


FIG. 3.

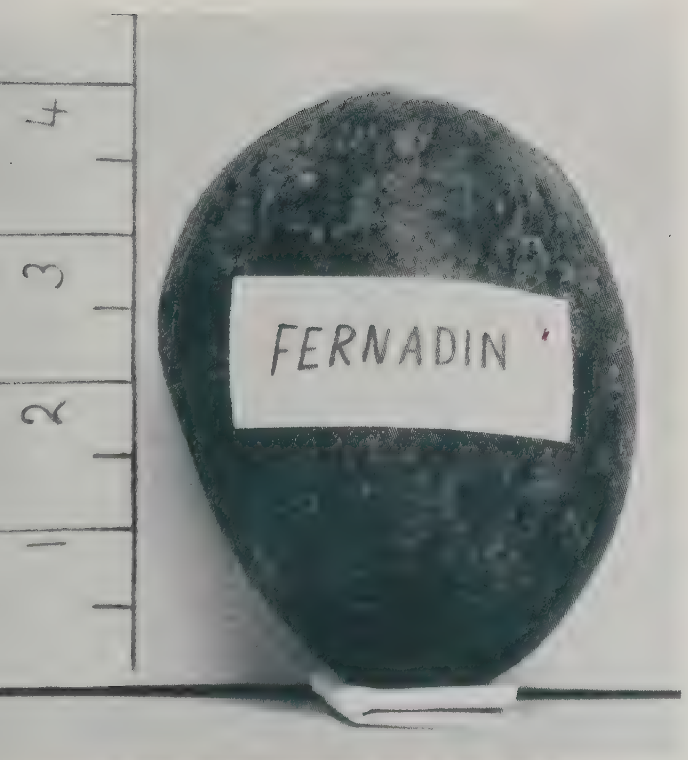


FIG. 4.

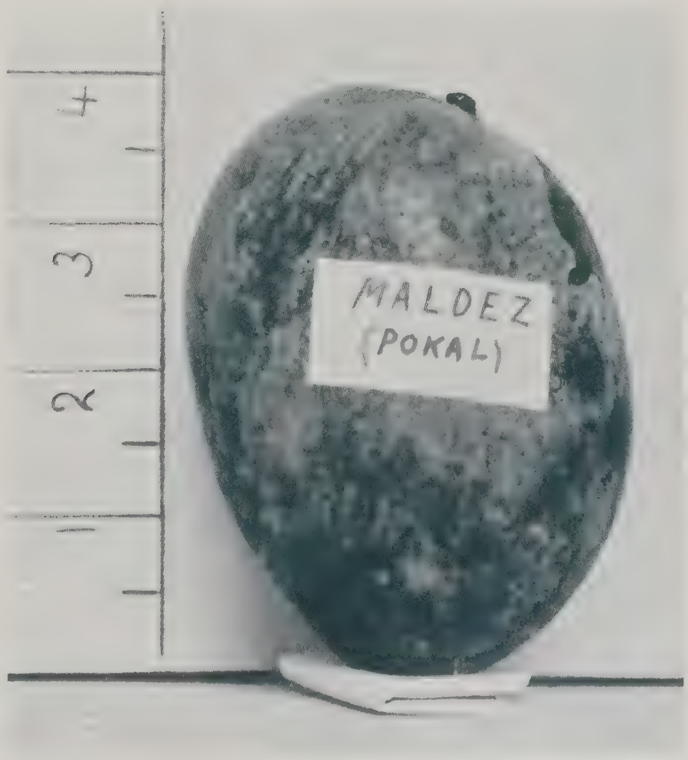


FIG. 5.

In Thorla-Goa a planter, who has a considerable area under mango, told me that in the year 1911, three trees fetched him in all sixty rupees, each tree bearing from two to three thousand fruits, whereas the following year, the same trees were sold for Rs. 15, each bearing not more than five to eight hundred fruits.

Suggestions :—Regarding this, I have got very little to say, as the trees bear profusely notwithstanding their struggle against all the diseases that have crept in. But it is true that very little attention is bestowed upon manuring and watering of the plants. Pruning of decaying and dead branches and removal of Loranthus which is becoming a more serious pest every day, is not done at all. If these things are looked to and if systematic pruning and manuring of the trees is adopted, the trees would bear immensely and would greatly benefit the people, who are already getting good returns from the fruits.

GROUND-NUT IN GUJERAT.

BY

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Superintendent, Model Farm, Baroda.

It has been generally supposed that ground-nut cannot be grown as a profitable crop in Gujerat. The knowledge of the early exotic ground-nuts, Spanish pea-nut and small Japanese, and the results obtained therefrom have, however, considerably altered this view and now ground-nut is one of the principal crops, recommended by the Agricultural Department to the cultivator. These varieties were first tried on the Government Farm at Surat, and naturally, therefore, the extension of the crop has taken place in S. Gujerat, of which Surat forms the centre. It must not be imagined, however, that the crop is extending by leaps and bounds; but that it is continuously on the increase and gaining ground with the cultivators, can be easily seen by the increasing amount of seed distributed. The chief limitations to its spread are—

(1) Its liability to damage from crows and jackals, and to theft.

(2) The high cost of its cultivation.

(3) Scarcity of labour at the time of harvest.

In the Deccan, in the Satara District, where ground-nut is extensively cultivated, this last difficulty is not so much felt in the case of the early varieties; for, being cultivated only on uplands, they mature at a time when labour is not particularly scanty. In the case of harvesting Pondicherry ground-nut, however, this difficulty does occur but does not form a complete bar to its cultivation, because it could be harvested later on by working

a heavy four-bullock harrow. Here, however, from this time onwards there is a continuous demand for labour in cutting grass, weeding, harvesting rice, etc., by the end of which time, if the crop be left unpicked, the soil gets too hard for working. It thus becomes necessary to harvest the crop when the soil is just suitable for easy uprooting.

The first difficulty is a real one, but as the crop becomes more general, losses from these sources will be considerably minimised ; and the crop itself is sufficiently paying and valuable to allow for careful watching. But the tendency now seems to be in a different, but well-known direction, *i.e.*, towards a mixed crop. *Urid* (black gram) is a very favourite mixture on this side both with *Jowar* and in some cases also with cotton. It is an easy step for ground-nut to take the place of *Urid*. Cotton being a crop of a longer duration than *Jowar* and of deep feeding habit, a mixed crop of cotton and ground-nut in different rows, adjusted to leave sufficient space for the cotton to spread after uprooting the ground-nut is likely to give the best results.

Recently the same crop has been tried on a considerable scale in the light *Gorat* soil skirting the river Tapti and the crop appeared so luxuriant and vigorous that the cultivation may tend to become a permanent one in such soils. The varieties most in request are naturally the small Japanese and the Spanish pea-nuts, though here and there demands for big Japanese and other late varieties are also made. It is very difficult to decide as to which is superior between the small Japanese and the Spanish pea-nuts. The general impression is that the small Japanese yields better, but it does not find a ready sale for consumption owing to its uninviting appearance and oily taste. The Spanish pea-nut, on the other hand, is a finely coloured, attractive nut, but gives less outturn. The earliness of these types naturally enables them to make a successful stand against a comparatively dry season, but it has been observed this year that there was no other crop that was so little affected as ground-nut by the abnormally wet season and that made so successful a stand

against it. This adds one more argument in favour of its cultivation.

But while such is the state of affairs in S. Gujerat, in N. Gujerat ground-nut cultivation is practically unknown, owing to a variety of causes, the principal of which is fear of white-ants. As in S. Gujerat, ground-nut also displays here the characteristic of making a good stand against both dry and wet seasons, while as regards white-ants, looking to the outturns of both last and this year, given below, it will appear that the loss on this account is considerably overrated.

I.

Variety.	Rainfall in 1911-12 14·48 inches.	Rainfall in 1912-13 40·56 inches.	
	Nuts.	Nuts.	Creepers.
	lbs.	lbs.	lbs.
Tamboo ..	2,000	2,656	6,080
Senegal ..	1,073	1,860	5,920
Small Japanese ..	1,453	2,336	3,800
Spanish pea-nut... ...	2,300	2,032	4,200

While thus, on the one hand, there is no appreciable damage from white-ants, it has also the rare fortune of being safe from the attack of *Katras* (hairy caterpillars)—a great scourge of most other crops.

Profit.

It must be confessed that the cost of cultivation is high, the two costly items being harvesting and seed charges. But to compensate for this, the net profits are also proportionately big, as will be seen from the table given below showing this year's figures of outturn, value and cost.

II.

Variety.	Outturn per acre.		Value of outturn.*	Cost of cultivation.	Profit.
	Nuts.	Creepers green.			
Late.	lbs.	lbs.	Rs. A. P.	Rs. A. P.	Rs. A. P.
Tamboo	2,656	6,080	175 8 0	113 0 0	62 8 0
Senegal	1,860	5,920	125 8 0	113 0 0	12 8 0
Early.					
Small Japanese ...	2,336	3,800	151 15 0	80 15 0	71 0 0
Spanish peanut ...	2,032	4,200	133 9 0	80 15 0	52 10 0

* The nuts were sold at Rs. 2-8-0 per maund of 40 lbs. and the creepers at one anna per 40 lbs.

Cultivation.

The main items of cultivation charges are roughly given below from this year's cultivation sheet of a varietal test.

III.

Operation.	Cost in early types per acre.	Cost in late ones.
	Rs. A. P.	Rs. A. P.
1. Preliminary tillage ...	7 12 0	7 12 0
2. Manure, 20 cartloads ...	19 8 0	19 8 0
3. Cost of seed and sowing 80 lbs. of kernels.	13 3 0	13 3 0
4. Weeding & interculture ...	9 5 0	9 5 0
5. Harvesting	31 3 0	63 4 0
Total ...	80 15 0	113 0 0

Cultivation of the crop begins with a ploughing with a B. T. 2 plough after the previous crop is removed, between December and March; manure is applied at the rate of 20 cartloads per acre in May. After the rains begin, the manure is mixed in with a plough and seed sown with a three coultered drill by about the last week of June. About ten days later, a hand weeding and hoeing is given and blanks are filled in. Another interculture and weeding is given a fortnight later. By the beginning of August the crop is once more weeded and intercultivated and by the middle of August a country plough is

worked between the rows to keep the soil loose. With a field in good condition, this is the last cultural operation, but one more weeding may sometimes be found necessary in September. In normal years, the early types ripen four months after planting. Owing to wetness of the season, however, this year they were harvested by the end of November. The late varieties were harvested a fortnight later, but showed no sign of want of water and were given none. These had to be hand-dug, an enormously costly operation, as will be seen from the above table.

A peculiar feature that is common to both early and late varieties is that the creepers do not dry and die down as is always the case in the Deccan. Not only this but new pods were seen forming even as late as November, so that at whatever stage we harvest the crop from October to December, some pods will remain immature. A peculiarity of the late types was that the pods were mostly formed and found within the depth of four inches. It may be due to the fact that these were not watered and so the soil, setting hard below, did not allow easy penetration for the elongated peduncle.

Line of Investigation.

On referring to the cost of cultivation table, it will be seen that leaving manure out of consideration, the other two costly items are sowing and harvesting charges. Even the manure cannot wholly be put to the charges of ground-nut alone. Below are given for comparison results from an unmanured field which shew that the crop was a good one under such conditions.

IV.

Variety.	Produce.		Value of outturn.	Cost of cultivation.	Profit.
	Nuts.	Creepers.			
	lbs.	lbs.	Rs. A. P.	Rs. A. P.	Rs. A. P.
Spanish pea-nut	2,546	4,733	166 8 0	54 3 0	112 5 0
Small Japanese	1,826	4,113	114 4 0	54 3 0	60 1 0

The cost of manuring, therefore, must be distributed over say three years, which will then increase the profits by another Rs. 10 to Rs. 12 in the case of statement II. The best way perhaps of applying this manure would be to give it to cotton with ground-nut and *Bajri* taken in successive years, making a complete three years' rotation of cotton, ground-nut and *Bajri*; for there is no doubt that good crops of cotton could be grown in this region.

The cost of seed could be reduced by experimentally testing how far the seed rate could be reduced with the best economic results. In the meanwhile, reserving one's own seed may considerably lighten the burden. But what is really burdensome is the cost of harvesting, which is so heavy in late varieties as to be almost prohibitive. It is probable that irrigation may conduce to reducing this somewhat, but whether it would bring it down to some reasonable amount can only be decided by experiments. Thus anything that will lighten this heavy burden will pave the way for popularizing the crop. Reference has already been made above to the fact that at whatever stage between October and December the crop may be harvested, a number of pods will always remain immature. The later they are harvested the heavier the charges become, but some more outturn may be realized. Early harvesting at a time when the uprooting will bring up most of the pods before the soil is completely dry, will reduce the cost, but to some extent the outturn as well. The best time, therefore, for harvesting the crop so as to leave the largest net profits can only be determined by fortnightly trials of harvests from October to December. Land commanded by irrigation can be harvested if a watering is given so as just to moisten the soil.

Conclusion.

It will be seen from the above that there are no obstacles—physical, climatic, seasonal, or agronomical to the cultivation of this crop, at least in parts where the conditions of soil and season like those of Baroda prevail. On the other hand, the crop has

yielded an outturn which will leave as good a profit as tobacco, the money-making crop of this tract; white-ants do not appreciably damage the crop, while it enjoys freedom from the attack of *Katras*. In addition, it opens up a way for systematic rotation. What really matters, and more so in the initial stages when the fields will be few and far between is the molestation of the crop by birds, beasts and thieves. It is to be hoped, however, that as the crop yields large profits, pains will be taken to watch and protect it and, as the area will extend, these depredations will be less serious. How the cultivators take it, the future will show.

NATURAL ROOT-GRAFTING.

BY

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The harmful effect of trees on crops in India is well known particularly in *barani* or dry crop areas where soil moisture is a limiting factor in production. Whenever a field is surrounded by trees, the soil moisture in the *rabi* season is notably deficient on the boundaries near the trees and only gradually increases towards the centre of the field. The effect on a crop is very soon evident. When the defect in moisture is very great, germination is affected round the edges of the field and, even if a few weak seedlings are produced, these wither away as the season progresses. If the soil moisture is more abundant at sowing time, germination may be even over the whole of the field, but the early promise is seldom or never maintained. Sooner or later the crop on the land affected by the tree-roots falls behind the rest, and commonly shows a yellowish, starved appearance. Such areas always exhibit all the phenomena of premature ripening. These are the obvious effects which result from the presence of trees near cultivated land. There can be no doubt, however, that the total effect is much greater than the observed effect and that larger areas are in reality affected. In all probability there is a gradual transition between the badly affected areas and the normal crop, and a good deal of damage occurs which is not evident to the eye, but which can only be detected by accurate weighments of the produce on fields in which other disturbing factors have been removed. Where solitary trees occur in cultivated fields, similar results are

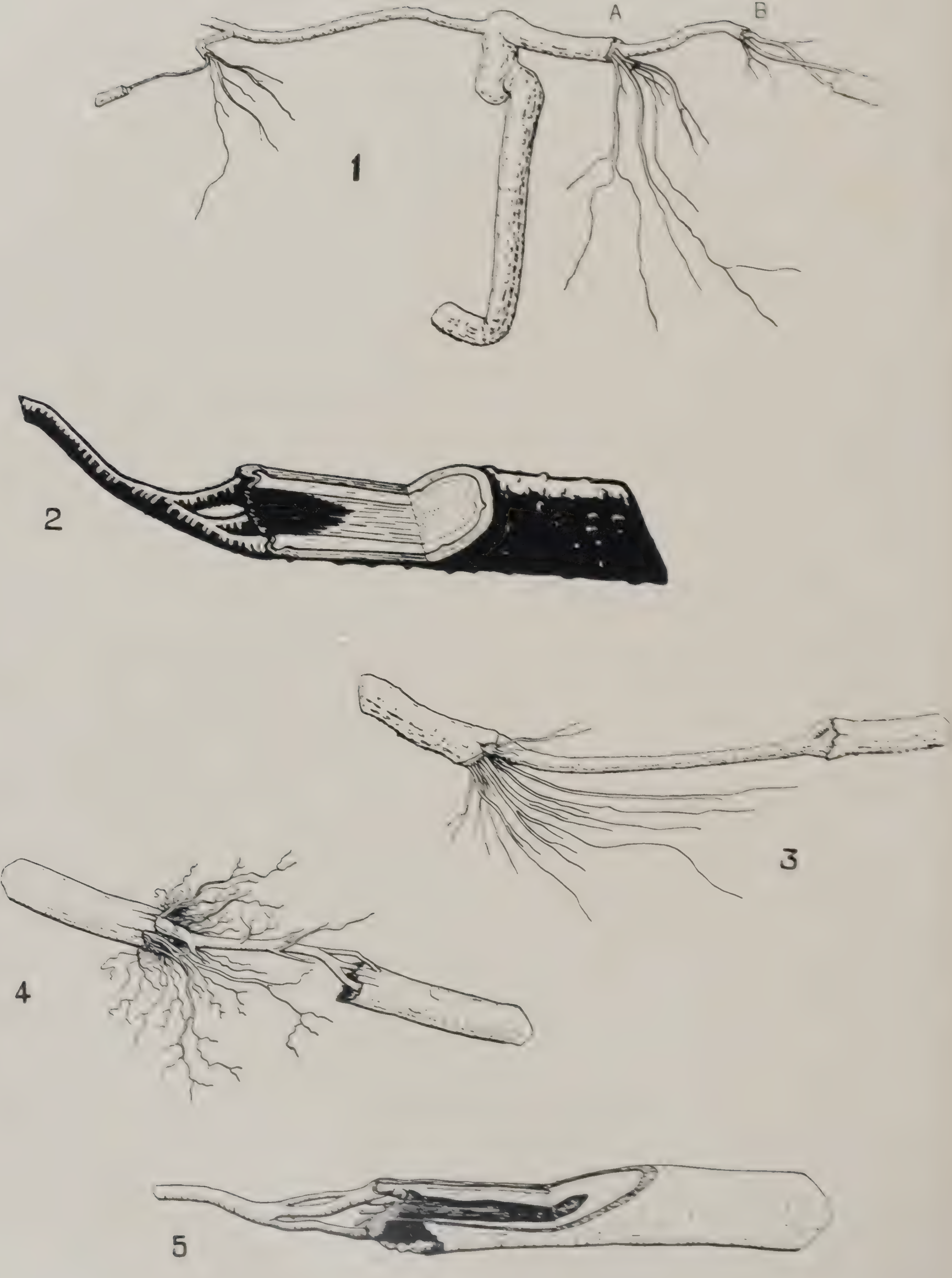
observed. The trees are generally surrounded by a zone of weak stunted plants, the effect varying with the season and with the kind of tree. The cultivators in the plains of India are fully alive to these facts, and clearly recognise the harmful effects of trees on their crops and are positive that some trees do more damage than others.*

In the laying out of the botanical area at Pusa, the harmful effect of trees on the cultivated land in the neighbourhood had to be considered, and great efforts were made to reduce this disturbing factor to a minimum. A large number of trees and bamboo clumps were removed altogether, while the influence of the few remaining was checked by cutting deep trenches every year between the trees and the cultivated area. In the case of bamboos and several trees this has been very effective, but in other instances cutting the roots has not led to any permanent results. In addition, an increased tendency of root encroachment has been noted since the present system of cultivation has been adopted, particularly in the case of the banyan and pipal. The distance to which the roots of the pipal extend is very great. At Pusa large roots were discovered under thin patches of crop at the following distances from the parent tree—183, 194, 206 and 217 feet.

Root-cutting was followed by negative results in the case of three trees—pipal, banyan and teak. In every case, a year after the roots had been cut, it was observed that the effect on the plots could still be detected. On carefully opening the old trenches in 1912, twelve months after the last root cutting, it was found in the case of the pipal and banyan that the severed roots had become connected and that natural repair had taken

* There is no doubt some trees appear to do much more harm to crops than others, at least the effect is more evident in certain cases. At Pusa, in addition to bamboos, the following trees damage the crops in their neighbourhood to a very marked extent—teak (*Tectona grandis* Linn.), tamarind (*Tamarindus Indica* Linn.), pipal (*Ficus religiosa* Linn.), and banyan (*Ficus Bengalensis* Linn.). The subject of the effect of different trees on cultivation is an important one in India and needs investigation. The results of such studies should be considered in all future arboricultural schemes. If possible, trees should be selected for avenues in the country which, while desirable as roadside trees, do the least damage to the cultivators' crops.

PLATE XXVIII.



NATURAL ROOT GRAFTING IN THE BANYAN AND PIPAL

place. This was accomplished by means of one of the numerous new roots, produced at the cut end of the root attached to the tree, growing across to the severed portion through from two to three feet of soil. The cut off portion of the root behaved as a cutting and did not die before union took place. Repair was in all cases effected by a process of natural grafting between the new roots and the completely cut off portions. This took place by the growth of the connecting root under the cortex of the severed portion when natural grafting occurred followed by a rapid thickening of the connection. The distances between the cut surface of the original roots varied from 24 to 30 inches, while the diameter of the new connecting part varied from 0·8 to 1·1 inches. This growth in thickness must have taken place in less than twelve months as some time must have elapsed after cutting before the connection occurred.

The details of this natural root-grafting are shown in Plate XXVIII. Figures 1, 2 & 3 refer to the banyan, while Figures 4 & 5 relate to the pipal tree. In Fig. 1 a portion of the banyan root system is shown. A large root is figured which suddenly bends vertically upwards and then divides into two horizontal portions both of which were cut when the trench of 1911 was made. At A the connection made in 1910 is shown, while at B the junction of 1911 can be seen. This case is interesting in view of the statements made by the cultivators that in both the banyan and pipal the roots come to the surface to feed at great distances from the tree and that the cutting of trenches six feet deep or so will not intercept all the roots. This is certainly the case in the pipal where some roots were not met with till a depth of nearly twelve feet was reached, while in the banyan, roots have been found as low as ten feet in trenches dug well beyond the spread of the branches. A section through the point of union in the case of the banyan is shown in Fig. 2. The decay at the cut end of the severed portion was very small and hardly exceeded two inches. The old wood is seen surrounded by a new growth of active wood which probably formed after natural grafting was completed. In Fig. 3 a case of complete repair is shown and

the cut surface of the severed end has been covered in completely by new growth. The corresponding details with regard to the pipal are shown in Figs. 4 & 5. The method of union in this case is the same as before, but more decay took place at the cut end, and the grafting process does not appear to be quite so rapid as in the case of the banyan.

Natural grafting was not observed in the case of the sissoo tree (*Dalbergia sissoo* Roxb.). Here the severed portions died and no case of natural union was found. In the case of the teak no natural grafting was seen, but in this tree the cutting of the roots was not followed by any permanent results in so far as the neighbouring crops were concerned. This tree appears to dry the soil in its neighbourhood much more than other trees, and it may be that the water content of the land is being continually lowered in the neighbourhood of the tree even beyond the range of the roots. In any case the digging of trenches six feet or more in depth between a teak tree and cultivated land has no permanent result in arresting the damage done.

From the point of view of the experiment station worker in India the subject of the effect of the growth of trees in the neighbourhood of cultivated land is an important one. This is particularly the case in the growth of *rabi* crops in the dry crop areas where soil moisture is a limiting factor in production. Certain trees appear to do more damage to crops than others—at any rate, the effect is more obvious in some cases than in others. All trees, however, are probably harmful as their presence must result in greater competition for the available supply of soil moisture. Besides the visible effect of the roots on the crop it is likely that a wider area is influenced by the roots and that the damage is much greater than would appear at first sight. Again when trees occur between cultivated and uncultivated land it is probable that root development is stimulated on the side towards the crops as here the supply of moisture and food material is likely to be greater than in areas under grass. In variety trials and field experiments where the aim of the experimenter is to reduce errors to a minimum, there can be no

doubt that the presence of trees introduces a disturbing factor. Until we know with precision the distribution of the root system of different trees and the effect on neighbouring land of the local reduction in soil moisture near trees like the teak it is impossible to estimate the amount of damage done. The ideal experiment station is one without any trees at all, but this is difficult to obtain on account of the prejudices often aroused by the cutting down of avenues and shade trees. Until the whole subject is better understood in India and the methods of conducting field trials are examined in detail, all that seems possible is to free a portion of an experiment station from trees altogether and to restrict critical field trials to this area. This naturally reduces the amount of work possible and interferes with the utility of the station.

IN DEFENCE OF THOSE AGRICULTURAL SCIENTISTS WHO ARE NO LESS AGRICULTURAL THAN SCIENTIFIC. A REVIEW.

BY

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There has recently fallen into the writer's hands a copy of "The Cotton Plant in Egypt—*Studies in Physiology and Genetics*" by W. Lawrence Balls, M.A., Botanist to the Department of Agriculture, Egyptian Government (Macmillan's Science Monographs).

This book which, as we learn from the preface, was written primarily "for those few Economic Botanists who are more botanical than economic," abstracts "the results of a series of researches made upon cotton plants in Egypt, ... connected by the desire to know all that could be learnt about the plant itself;" and if the lay reader is predisposed by this introduction to look somewhat critically for any other motive connecting these researches, and hardly feels disappointed at his inability to find any, it may perhaps be ascribed to his sense of irritation at the invidious distinction between pure and economic botany, implied by the author.

Possibly no reader of the book, certainly not the layman, will question its thoroughly "scientific" character. It is a mass of figures, diagrams and curves in which are presented quantitatively in what is, from the mathematical point of view, the most concise and intelligible form, the variations in the environment of the cotton plant in Egypt and in its physiological functions:

the correlation between the two being worked out in a large number of cases after the methods popularised by Galton and Karl Pearson.

And, without the technical knowledge to enable him to form an estimate of the skill and judgment with which these methods have been used, the reader is free to admire the ingenuity and industry displayed by the author in their application. Indeed, one puts down the book with a feeling that one has seen all the most recent machinery of science called in, to collect data and construct a series of mathematical formulæ which would probably, if one ever happened to be in circumstances in which they would be of any use, prove quite reliable.

But at the same time one feels that by the use of a little commonsense, a little intuition, by taking even a slightly broader view, one could probably always, and with advantage, avoid being reduced to the point of having to use them. Who, for instance, that has gardened in a hot climate, does not know, by the intuition derived from many little unrecorded observations, the stunting effect of the afternoon sun in dry weather, shown in extreme cases by the flagging of leaves and remedied by judicious pruning or shading ; or again the unhealthy appearance of plants that are suffering from water-logging either owing to bad drainage or heavy and prolonged rain : and why—why is it necessary to measure and record, as the author has done, the exact value of the factors concerned in any particular case ?

If it is really, as the preface implies, only the desire to know *all* that can be learnt about the plant itself, the book can only be regarded as a contribution towards the accumulation of what Professor Soddy* calls the "mere knowledge" . . . "however complete and accurate" which will go to "deaden rather than develop the intellects" of future students of Physiology and Genetics.

But if we assume that these investigations are not blind alleys, that the author had in view some scientific object for

* Matter and Energy. Williams and Norgate, 1912.

the ultimate attainment of which these—may one say—*sordid* quantitative investigations are essential; the fact remains that the large amount of work here recorded does not appear to be of any immediate economic importance.

Moreover, it may be suggested that even from the scientific point of view, the expenditure of time by an official of an Agricultural Department on such work is a mistake.

If we cannot quite logically say that science was made for man and not man for science, it is at least questionable whether the soundest view to take of the work of a scientist paid in any interests, is not that he should be guided primarily by the economic requirements of the interests in which he is paid. We know that the rendering to Cæsar of the things which are Cæsar's is not incompatible with the highest of ideals.

No one will deny that apparently unimportant scientific investigations have often led to most important practical results, but it is legitimate to assume that, other things being equal, such results would have been more systematically of economic importance if the importance of economics had been kept more systematically in view in directing the investigations.

It is questionable whether the field of so called "pure" science should not be left to those whose circumstances permit them a perfectly free selection of phenomena to investigate.

For indeed the purity of a science is only the purity of motive, choice, and vision of the investigator, and a careful estimation of the relative importance of the different aspects of the phenomena investigated, from the point of view of the interests in which the investigations are undertaken, is an antecedent condition of the purity of the scientific work of a paid investigator.

The purity of the science of Astronomy arises, not from the fact that its economic application is for the most part indirect, but because, this being so, its relative simplicity and attractiveness for the human mind have resulted in its being studied for its own sake apart from any economic considerations; *per contra* it can only add to the purity of an economic investigation if it is

based on a primary choice of phenomena of economic importance to investigate.

From this point of view such an investigation of the cotton plant in Egypt should begin at the diametrically opposite pole from that of "studies in Physiology and Genetics." The agricultural conditions should first be studied, from the agricultural standpoint, with a view to the acquisition of that intuitive sympathy with the plant, that comes from even a comparatively short, if detailed, personal acquaintance with the scientific application of the ordinary agricultural operations of draining, cultivation, and irrigation—an intuition which integrates in itself the results of numberless observations of the continuous interplay of physiological phenomena, in a way that the merely mathematical investigation of isolated factors can never emulate; just as the perfectly automatic nature of the control of the beating of the heart, sums up phylogenetically and better than could be contrived by any conceivable proficiency in medical science, the practical experience of æons in the regulation of blood circulation.

The conditions for the production of the optimum agricultural results having thus been brought within the control of the investigator, the isolation, by breeding and selection, of those characters of the plant that are directly or indirectly of positive economic importance under local conditions becomes a comparatively straightforward, if massive, piece of work—to be followed by the synthesis of such useful characters as are not incompatible.

It is not implied that the work is easy, or that there is not ample room for the exercise of scientific accuracy in the preliminary observations on the growth, habit, pollination, etc., of the plant, but such observations are essentially qualitative and do not necessitate exact quantitative estimations of the physiological relations between plant and environment, any more than due attention to the points of—shall we say—liveliness and 'skin' of a milch cow, necessitate a measurement of the length of her paces or of the composition, diameter and number per square inch of hairs on her flanks. It is only some of the more important

economic characters of the plant that require exact quantitative comparison, and this can be made relatively simple.

It is a matter for regret that the author should have added one more to the list of scientific books that give cause for the enemy to blaspheme. May one express a hope that his obviously great gifts of intellect and energy may be turned from pedantic devotion to a merely mathematical ideal into channels of more practical, and therefore from an economic point of view more pure, scientific interest.

NOTES.

THERE have recently been conducted at Coimbatore some feeding tests to ascertain the benefit to be obtained by chaffing fodder (sorghum straw) as against the common system of cutting or breaking it into lengths of 12 inches to 18 inches. The method adopted was to give the animals their normal concentrated ration of $1\frac{1}{2}$lbs. cotton seed and $1\frac{1}{2}$lbs. of groundnut cake, along with a minimum ration of chaff. This was then changed to chopped fodder, which was gradually reduced until the animals just showed signs of losing weight, when the same quantity of chaffed straw was substituted. The test was made on six animals for the first two months, and four animals for the last six weeks.

The experiment has been a failure, probably from two causes. Firstly, it was not possible to arrange uniform work for the animals during successive periods of feeding, as at the start of the experiment they were engaged in the heavy work of lifting water, while at the end they were doing light carting work. Secondly, all the animals showed extraordinary daily fluctuations in their weights, amounting at times to more than 10 per cent.

The writer would be glad if any of the readers of this Journal can corroborate these difficulties from their own experience or throw any light on the variation which may be expected in *working* animals ; most feeding tests are of course concerned with fattening animals. In conclusion it may be said that the experiment was conducted as accurately as possible in the condi-

tions obtaining in a well-equipped provincial station.—(R. Cecil Wood).

A paper in the Journal of Agricultural Science, Vol. III, Part 4, by Professor Wood and Mr. Stratton, of Cambridge, gives the probable error in cattle-feeding experiments as 14% of the live weight increase for a single animal. Considering the additional difficulty of measuring the amount of work done by working animals, it is probable that a number of animals far greater than those mentioned in the above note, would be needed to render the results at all significant.—Editor.

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* *

The following extract from a summary in *Nature* of the discussion on animal nutrition at the last meeting of the British Association, may serve as a warning to any who may tend to place too much reliance on chemical analysis of food-stuffs as a guide in the feeding of livestock. Incidentally it also affords testimony in favour of Bombay cotton cake as a food-stuff :—

"For the past ten years an important series of sheep and cattle feeding experiments has been carried out by Mr. Bruce, and the results were very ably summarised by Mr. Watson. A remarkable feature was the pre-eminent position of linseed cake as a food, animals fed on this always making greater progress than those on other substances. Better results were also obtained with Bombay cotton cake than with Egyptian cotton cake, in spite of their apparent identity on chemical analysis. A mixture of wheat, cotton-seed and cotton cake made up to give the same analysis as linseed cake proved economically a failure. The conclusion is drawn that our present methods of valuing feeding stuffs do not afford particularly useful information. Prof. F. G. Hopkins dealt with the discrepancy. Until recently physiologists had been content to express diet in terms of energy and protein minimum, neglecting other factors. It is now known that these other factors do matter, and that one cannot group together all the constituents either in terms of a starch equivalent or of any other unit. There are other constituents just as important as carbohydrate, protein, or fat, and if these are

removed, the diet may lose much of its value or even predispose to disease. Dr. Fünk gave an actual illustration in the work that he has been doing at the Lister Institute on the isolation of the so-called vitamine from rice polishings."

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THE MANGUM SYSTEM OF FIELD TERRACING.—This system is described in Circular No. 94 Bureau of Plant Industry of the U. S. A. It differs from other systems of terracing in having a broad terrace bank of about 15 feet in place of the usual narrow strip of grass. The bank comes under cultivation with the rest of the field, and it is claimed that the system saves a great waste of land and of labour in cultivating and weeding and has the effect of keeping down weeds and diminishing the damage done by insects.

A convenient way of laying out the fields is described in the circular and also a cheap form of level for laying off the terrace lines. The terrace banks are built up by repeated ploughings round the terrace lines as crowns. A gradient of ½ inch in 14 feet is considered the most suitable for the terrace lines which are usually laid off at intervals of 6 feet of fall in the slope of the land.

The banks once made require little attention. In fields of ordinary slope the terrace may be disregarded, except that all dead furrows should be filled up in ploughing across. On extremely steep land however the ploughing is done in contours.—(S. MILLIGAN.)

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NITROLIM.—Not many years ago some eminent scientists predicted a nitrogen famine and the rapid exhaustion of the world's supply of available nitrogen was a source of great concern. But it was not long until it was discovered that atmospheric nitrogen could be fixed by means of the electric arc, and thus an inexhaustible store-house was thrown open. Soon the methods for the fixation of atmospheric nitrogen were improved upon and cheapened until it became possible to produce it in large

quantities to compete with nitrate of soda and sulphate of ammonia. Norway leads in the manufacture of this new fertilizer known as cyanamide or nitrolim, and if the plans of the Norwegian Hydro-electric Nitrogen Co. mature by the close of 1916, waterfalls in Norway to the enormous total of 540,045 horse-power will be utilized in the manufacture of nitrolim.—(*Philippine Agricultural Review*, January, 1913.)

It has for some time been evident that the supply of combined nitrogen is only a question of the energy available for effecting the necessary combinations. But that the amount of such energy required will always be considerable is shewn by the power of nitrogenous explosives.

The sources of power are being rapidly appropriated as the above extract shows, and it is only a question of time when its use for increasing the production of food for the general mass of humanity will begin to compete with its use for such special purposes as, *e.g.*, motoring.

From this point of view, may not the disproportionate rise of food-prices in India be regarded as the result of a similar competition between the relatively specialised activities of the West and the massed populations of the East, now brought into closer contact by improved communications?

When an industrialised Asia begins to import food, and famine ceases to restrict the growth of her populations, Europe will be faced with a new situation.—(A. C. DOBBS.)

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JOURNAL OF THE MADRAS AGRICULTURAL STUDENTS' UNION.—The past students of the old Saidapet College and the past and present students of the Agricultural College, Coimbatore, have formed a Union under the name of "Madras Agricultural Students' Union." Its principal objects are to foster a spirit of brotherhood among the students and to exchange ideas. It also serves as a bureau for procuring employment as far as possible for its members. It is two years since it was organised and in this short period it has been able to enrol 138 members.

When the proposal for the formation of this Union was mooted, some of the old students suggested that its objects would be best achieved by the issue of a periodical publication. In response to this suggestion the Union has started a Quarterly Journal called "The Journal of the Madras Agricultural Students' Union," the first number of which is to hand. It contains useful information regarding the College and the Agricultural Department, and simple articles on agricultural subjects.

To afford its members an opportunity of meeting and exchanging views, the Union holds a gathering every year in July. Two such gatherings have been held and have been attended by officers of the Agricultural Department and by rich zemindars. The principal feature of this annual gathering is the holding of a Conference on the day of the gathering at which papers on agricultural subjects are read. At the Conference held in 1912, several papers were read of which those by Dr. C. A. Barber on "Sugarcane Seedlings in India," and by R. B. J. Dharmaranga Raju on a "Suggestion for accelerating the introduction of Agricultural Improvements in the Madras Presidency" have been published in the first number of the Journal of the Union. The former has since been published in the October (1912) number of this Journal.

REVIEWS.

"SOIL, ITS TREATMENT AND AGRICULTURAL IMPLEMENTS." A PAMPHLET IN MARATHI BY RAO SAHEB G. K. KELKAR, ASSISTANT PROFESSOR OF AGRICULTURE, AGRICULTURAL COLLEGE, POONA. Price As. 8.

THE aim of this Vernacular publication is to place before the cultivating classes, especially those of the Deccan, all the available information on the subject of improved agricultural implements which have been successfully tried on the Farms of the Bombay Presidency. After describing briefly the conditions of soil and climate obtainable in the Deccan and the improved methods which should be adopted for the preparation of the various classes of soil in order to ensure the largest possible outturn, the author gives an illustrated description of the various implements necessary to bring about the desired improvements. The advantages of iron ploughs, harrows, etc., in reducing the soil to a fine tilth—a condition which is so necessary for the conservation of soil moisture in tracts like the Deccan where the rainfall varies from 15 to 30 inches—are fully discussed, and every other information about these appliances (such as cost, methods of using, etc.) is given. Besides tillage implements, the author also supplies similar information about seed drills, threshers, winnowers, chain pumps, etc., the advantages of which have first been ascertained on the Government Farms. In short, the pamphlet contains all about useful agricultural implements tried on the Bombay Farms and is likely to serve the purpose for which it is written—namely, to spread the knowledge of such appliances.

A similar publication in English issued by the Mysore Department of Agriculture has also come to hand.—(S. D. M.)

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NAKHLISTAN, PART I. BY ABDUL KADAR KHAN, PRINTED AT THE UNION STEAM PRESS, LAHORE. Price As. 8.

THIS book has been written in Urdu by a resident of Multan District, who claims that he has over 18,000 date-plants in his own garden, but the reader will be disappointed to find that very little has been written from personal experience.

The bulk of the subject-matter has been taken from different English papers, and badly translated. Especially in dealing with scientific points the author has himself been confused; for instance, under pollination he writes on page 66: "In the matter of sex the date-palm is quite different from other plants. In other plants when flowers are borne one is male and the other is female, etc., etc." The general language of the paper also requires revision.

There are 8 chapters in the book as follows:—

(1) Soil and climate.
(2) Preparation of land and manure.
(3) Method of planting.
(4) Time of selection from the nursery.
(5) Arrangement of plants.
(6) Pollination and pruning.
(7) Nourishment, watching and irrigation.
(8) Diseases.

Every chapter contains many useful points, though in some cases the information given is misleading.

At the end the author gives a statement of the different varieties of date-palm with the names of countries in which they are grown, and as is often the case he forgets his own country and gives no names of any varieties found at Multan and in the neighbouring districts.—(A. R. K.)

The Bulletin of Agricultural Intelligence and Plant Diseases for December, 1912, issued by the International Institute of Agriculture, contains under the heading of "Edaphism," an abstract of papers by G. Gola of the Botanical Institute of the University of Turin on the relations between the plant and the soil, with particular reference to the chemical and physical constitution of the soil-water ; and gives, in a very condensed and dogmatic form, the conclusions drawn by the author from his researches. Many of these are of interest from the point of view of Indian agriculture, and the following extract is given as a specimen.

"The *drying up of the soil* even at ordinary temperatures causes a very considerable increase in the amount of soluble substances before the advent of rain ; a light rain in such a case produces a highly concentrated medium around the roots of plants, whilst continued rain causes a much greater impoverishment of the soil than if the soil were to keep fresh and slightly moist. The influence of drought on the increase of soluble substances is least in soils very rich in neutral salts (sodium chloride, magnesium sulphate), and much greater in those containing alkaline substances in a state of complex combination. The increase of salinity of the dried soil is due in the first place to the dehydration of many compounds of the soil itself, and also to the ascent by capillarity of the saline solutions existing in the lower layers of the soil and which concentrate at the surface, causing the formation of crusts and even of efflorescences. This is important because it allows the return to the surface of substances which had been dragged by the rain down to the deep layers of the soil. In this mobility of the substances contained in the liquids of the soil, the most important part is played by crystalloids, the least by colloids. Lastly, the superficial drying and consequent ascent by capillarity of saline solutions is much more marked in averagely porous soils, and its effects being more felt in regions subject to long alternating periods of drought and of rain, it may cause very great oscillations in the concentration of the liquids surrounding the roots."

Other interesting abstracts in this number relate to the "Effects of Continuous Cropping and Rotation on the Bacterial Flora of the soil" and to the "Lateritization of the soil under Arid Climates."

This useful monthly bulletin has now been issued regularly since November 1910 and the need of an index to facilitate reference is becoming urgent.—(A. C. D.)

UFRA OF RICE.

PLATE XXIX.

Fig. 1.—Ufra of rice. Advanced stage of *pucca* ufra, showing the thinning of the stem above the top node and the discoloration at the base of the ear. Most of the grains are light. Specimen from Narayanganj. $\frac{5}{6}$ natural size.

,, 2.—Ditto from a Pusa inoculation. The stem lesion is less marked than in fig. 1 and the base of the ear is not affected. $\frac{5}{6}$ natural size.

,, 3.—Ditto from a Pusa inoculation, with sheath still in place, showing the characteristic symptoms of *pucca* ufra. $\frac{5}{6}$ natural size.

,, 4.—Ditto. A typical case of *thor* ufra of aus paddy from Begumganj. Natural size.

UFRA DISEASE OF RICE.

BY

E. J. BUTLER, M.B., F.L.S.,

Imperial Mycologist.

Diseases of rice are, fortunately, not common in India. Compared with the other staple cereal crops of the country, wheat, millets, etc., the rice plant is remarkably free from serious fungus enemies. Of the two main classes of fungus diseases of cereals, rust and smut, the first is unknown on rice, the second rare. Insect pests are numerous, but usually they attack single plants scattered through the fields and, though responsible in the aggregate for great losses, the individual ryot gets a crop which repays him for his labour and is, therefore, not inclined, as a rule, to take them seriously.

In 1908, however, a disease of a new and much more virulent type was reported to be ravaging the paddy crop in the districts of Noakhali and Tippera at the head of the Bay of Bengal. It had been known for a good many years but had recently increased in severity to such an extent as, according to local correspondents, to bring the cultivating classes to the verge of ruin. The cultivators called it *ufra*, from "upara" meaning "above," associating it in some mysterious way with the sound of the "Barisal guns," a curious booming noise heard in the autumn in the Sundarbans and deltaic districts of Eastern Bengal.

Further enquiry has shown that the disease also occurs in the district of Dacca. Excepting these three districts it has not been heard of elsewhere as yet, but it is spreading and may be discovered before long in neighbouring districts.

The symptoms of ufra are sufficiently characteristic, though in the earliest stage the cultivator recognises that his crop is affected, through signs which might readily escape the notice of a less expert observer. At about the fourth or fifth month of growth, the tips of the leaves are found withering and the young shoots are pale and flaccid. Later on, brown stains appear on some of the upper leaf sheaths. Little else is noticed until the plants are about to come into ear. At this stage many plants are found with the top of the shoot swollen into a spindle-shaped thickening, which, on examination, is discovered to consist of the immature ear, enclosed in its sheath. In very many cases the enclosed ear remains thus imprisoned up to harvest, when it is generally found mouldy and rotten. This condition is known as *thor* (swollen) ufra. In other cases the ear escapes wholly or in part from the sheath, but the lower grains fail to develop and the upper are usually shrivelled. The term *pucca* (ripe) ufra is applied to this form. The upper sheaths, especially that which surrounds the ear, are withered or marked with characteristic brown stains, as may be seen depicted in the plate accompanying this article. On removing these sheaths the stalk is found blackened and shrunken for an inch or so just above the upper stem joints, especially the joint which carries the ear and that next below. Other minor symptoms are sometimes present, but the above are the usual outward signs of the disease.

The cause of ufra remained obscure for some time after its investigation was commenced. Recently, however, it has been determined to be due to a minute worm, belonging to the nematode or eelworm class, several of which are known to live parasitically on animals and plants. The species which causes ufra is one not previously known, but it belongs to a genus (*Tylenchus*)* in which are included two of the worst worm parasites of cereals. *Tylenchus tritici* causes the well-known ear cockles of wheat, which is found in the Punjab and is common in Europe ; *Tylenchus dipsaci* lives in the stem of several cereals,

* A more technical account of the disease and of the organism which causes it, is in the Press as Bulletin No. 31 of the Agricultural Research Institute, Pusa.

as well as in clover, onions, potatoes, etc. The rice parasite is allied to the latter, but is smaller and lives on the outside of the tissues, not embedded in them as is the case with *Tylenchus dipsaci.*

The parasite (*Tylenchus*) which causes ufra. Much magnified.

In the earlier stages of attack the worms are found chiefly in the inner layers of the leaf-bud in the neighbourhood of the growing point of the stem. In *thor* ufra they congregate on the shrunken, blackened portion of the stalk and at the base of the ear. Some are also found within the empty glumes of the ear. In *pucca* ufra they are found in the same places but the ear is more extensively infested, the worms lying within the glumes but outside the grain proper, when one is developed.

The individual worms are very minute, usually less than one-twenty-fifth of an inch in length, by one-fifteen-hundredth of an inch in breadth. They are therefore practically invisible to the naked eye. When a large number congregate in one spot, they

form a whitish cottony mass. Adult males and females, larval forms and eggs are usually found intermingled. As in the other species of the genus, the mouth of the adult is furnished with a minute spine, which can be protruded and retracted when feeding. The œsophagus has a stout muscular bulb, by the movements of which the plant juices can be sucked up, after the cell wall has been pierced by the spine.

The number of eggs laid by the female is not known, but is probably between 50 and 100. In *Tylenchus tritici* as many as 2,000 are laid. If the rice worm lays 100, which all reach maturity and are equally male and female, one pair could produce a quarter of a million individuals in three generations. It can readily be seen that the powers of multiplication of such a parasite are immense.

Up to the present it has only been found on rice. A wild grass was reported in one instance to suffer from the same disease as the neighbouring paddy, but the observation has not been confirmed. On rice the worm has only been found on the above ground parts, where it tends to work its way under the leaf sheaths and round the edges of the inrolled leaves into the heart of the bud. It has not been found in the roots, in the soil or on the numerous weeds which occur in the paddy fields. Naturally such a search is difficult and it is by no means certain that it will not be found in the soil. In dry paddy stubble from diseased fields it is common, and experiments have shown that it can stand drying, in some cases, for at least fifteen months without being killed. *Tylenchus tritici* possesses this faculty to a marvellous degree, having been found still alive after 27 years in dry blotting paper. Total immersion in water is not so well resisted, none being found alive after four months, unless the water was very pure.

In the months from July to November the worms are actively motile, moving with considerable rapidity in water by vigorous wriggling contractions of the body. In December their motility has practically ceased and they lie coiled up in the ears and stubble after harvest. It is not probable that activity is resumed before the flooding of the fields, which results from the

rising of the rivers in the hot weather and early in the rains. Hence active spread of the disease is confined to the second half of the year. How many generations occur within this period is not known, but there appear to be not less than three.

The observations so far made indicate that the parasite is restricted in its choice of food to living paddy plants. It neither feeds, nor multiplies, except when it is living on the growing crop. As soon as the crop is ripe it coils up and becomes dormant. It is true that it must travel through the water from plant to plant during the time when infection is actively going on, and we have found by experiment that if placed in water at the base of a paddy plant, it will climb up above the water level and work its way into the heart of the leaf-bud; but it does not seem to feed or multiply except on the plant itself, and if kept in water soon becomes sluggish. The experiments on this point are, however, not conclusive, as it is difficult to imitate all the conditions which may affect the natural life of the worm, when carrying out experiments in the laboratory.

In feeding on the rice plant the worm is restricted to such parts as are without strongly thickened cell walls in the outermost cell layer. The spine by which it pierces the wall to suck the juices, is small and very slender. It is entirely unfitted for the penetration of a stout or rigid barrier. This explains the peculiar localisation of the injuries on the stalk, ear and leaves. The outer wall of the stalk is thick and silicified, except for a short distance just above each joint, especially towards the top. Here it is thinner and flexible and here alone the stalk is attacked, causing the blackened shrunken areas well seen in Plate XXIX. The young ear is also not protected by thick outer walls. Large numbers of worms have been found feeding in this locality. The same is true of the young inrolled leaves which form the inner layers of the bud and also, to a less extent, of the inner surface of the leaf sheath, especially towards the free margins. It is in these last positions that the parasite is always found in the earliest stages of the attack.

In considering the amount of damage capable of being caused by this disease, and the possibility of its effective check, account must be taken of the conditions of paddy cultivation in the infected area.

In the three districts mentioned paddy is the staple crop, occupying over 70 per cent. of the cultivated area. About 3,000,000 acres of paddy are sown every year, though, as the land from which two crops of paddy are taken in the year is counted twice, the net acreage under the crop is probably only from $2\frac{1}{2}$ to $2\frac{3}{4}$ million acres. The total outturn is about 1,100,000 tons of clean rice. It is clear therefore that the interests involved are very great.

As is usual in the Eastern Delta Districts of Bengal, there are three main crops of paddy in the year, the "aus," the "aman" and the "boro," each sub-divided into a number of varieties or races.

The "aus" is sown, in this area, from the middle of February onward to the beginning of May, depending to some extent on the character of the land and on the season, and is harvested from July to September. It is usually grown on land slightly higher than the rest of the paddy fields, a few inches being often enough; the object being to select land which will not get deeply submerged in the early part of the monsoon. In much of Noakhali, however, "aus" is grown on low lands (but not the very lowest) mixed with "aman" and sown as early as possible, each crop being harvested as it ripens; early maturing varieties of "aus," harvested in July or the first half of August, being selected for these low lands. "Aus" is almost always broadcasted, though a little is transplanted. About one-third of the gross area is sown with "aus." It yields less than the "aman" and the grain is inferior to the better class of the latter.

The "aman" may be divided into two main classes, the long stemmed or deep-water rices, which form the bulk of the crop in this area and are sown broadcast alone or (especially in Noakhali) mixed with "aus," in March to the beginning of

May, and the transplanted or short stemmed "aman" ("sail" or "roá") sown in seed beds from May to July and transplanted in August and September. Both classes are harvested in November and December. The deep-water varieties are coarse and withstand flooding to a remarkable extent, being said to grow as much as 9 inches in 24 hours and to reach a length sometimes of 20 feet. When grown mixed with "aus" they are known as "bajal," the mixture being half and half or, more often, one-quarter "aman" to three-quarters "aus," in Noakhali. The deep-water rices are grown in the lowest lands and in some places, where the inundation is early, have to be sown in February. They keep pace with the rise of water and at harvest only the ears and 1 to 1½ feet of stalk are cut, the rest, often many feet in length, being left as stubble. A cold weather crop of pulses, such as Khesari (*Lathyrus sativus*), is sometimes sown on top of the paddy just before harvest.

Transplanted "aman" is grown either as a single crop, or as a first crop followed by cold weather pulses, or as a second crop following "aus" paddy or jute. The best varieties are grown on the higher lands. In the Western part of Noakhali little transplanted paddy was grown until recent years, according to local information, but there is now about 20 per cent. of this class in the neighbourhood of Chaumuhani. This is partly due to the extension of jute cultivation, the transplanted paddy being taken as a second crop, partly to the ravages of ufra on the broad-casted crop. The seed is grown in seed beds until the jute or unmixed "aus" is harvested, then transplanted into the higher fields after a few ploughings at the end of August or in September.

"Boro" paddy is of much less importance than the other two, being practically unknown in Noakhali and occupying only a comparatively small area in the other districts. It is grown on muddy land along the rivers and creeks. It is generally transplanted, but sometimes broadcasted on the mud flats. When transplanted, the seed is sown in late October or November, and planted out, usually without any previous preparation of the

land, in December or January. Irrigation is required, except where tidal water reaches the fields. Harvest is in April or May. The yield is heavy but the grain is coarse. Broadcasted "boro" is sown in December or January and harvested at the same time as the transplanted.

It will thus be seen that the chief paddy harvest is in November and December. The broadcasted "aman" (including the "bajal") leaves a quantity of coarse stubble in a matted mass on the still damp fields. This stubble is almost worthless as cattle fodder but the cattle are often turned loose to pick up what they can of weeds or rotting stubble in the fields. In the northern part of the district under consideration the fields are sometimes raked clean and the *debris* burned, but this is certainly rare in Western Noakhali. Ploughing is said to be sometimes done immediately after harvest but this again is unusual in Noakhali, where the first ploughing of the low lands appears to be usually in February, after a fall of rain. The early showers in February and March are extremely important in softening the heavy clay of the land subject to inundation, sufficiently to admit of ploughing with the inferior work cattle of the district. The fields which grow cold weather pulses, sown in the mud before the paddy harvest, are not worked until these crops are harvested. What remains of the stubble is often collected for fuel before ploughing begins. Five or six ploughings are given in February and March, or later in the higher lands. The tillage operations naturally vary in the different qualities of land and for the different classes of paddy it is intended to grow, but, as far as I can ascertain, the low land, on which deep-water "aman" and "bajal" are grown gets less cultivation than the others and may even be under paddy for 9 or 10 months of the year, and have stubble on them for a month or more after harvest.

Ufra has been found in "aus" and "aman" but has not as yet been reported in "boro" paddy. In Noakhali the first attack is found in the "aus" crop, both that grown alone (not common) and that in the "bajal" mixture, about the end of June, when the crop is beginning to come into ear. It occurs at

first in patches which do not spread with great rapidity; though the loss in a given patch may be complete, the total amount of damage to the "aus" crop is not large, as harvest occurs before the attack is widespread. At the time of the severest "aus" attack early in August, the broadcasted "aman" is still less than half grown and shows no sign of ears. Careful examination indicates that the latter crop has, however, the early symptoms of disease even at this stage. It is, indeed, probable that signs of infection could be detected in the "aus" before June, but an opportunity has not occurred for examination in the early stages of its growth. In the broadcasted "aman," whether alone or mixed with "aus," whole fields may be clearly diseased in late August and September. It is probable that there is no real difference in susceptibility between the "aus" and the "aman," but that there is a progressive multiplication of the cause of the disease insufficient to do much harm to the former but capable of great damage to the latter owing to its longer period of growth.

It is possible to find plants at the margin of spreading patches of disease, especially in "aus" paddy, showing some shoots with normal ears, others with different stages of *thor* and *pucca* ufra. Towards the centre of such patches, where the disease has been longer in progress, every ear is generally affected. Fields were seen where the loss did not exceed ten per cent. and others where it was practically complete. In "aman" paddy the intensity is generally high, as the long growth period allows the parasite to multiply greatly.

Perhaps the most remarkable circumstance in connection with the disease is the comparative immunity of transplanted paddy of any kind to natural attack. Transplanted paddy appears to be never severely attacked. Indeed it is not certain that it is ever attacked at all, but some suspicious cases were seen in transplanted "aman" about harvest time. These were, however, complicated by the attack of aphids and borers. On the other hand it is quite easy to inoculate transplanted paddy artificially, either by inserting a piece of diseased culm, bearing living worms, under the leaf

sheaths, or by merely placing similar pieces in the water at the base of the plant. Hence it is, apparently, not so much any inherent difference in the susceptibility of transplanted paddy to attack that explains why the transplanted crop as a rule escapes, as some peculiarity in the behaviour of the parasite which prevents it from reaching the crop. It is not yet clear what this peculiarity can be.

Owing to the backwardness of the affected tracts and the comparatively recent date of the organisation of the local Department of Agriculture, accurate information as to the extent of the area affected with ufra, and the amount of damage caused. is not yet available.

In Noakhali District the disease occurs throughout the central and western portions of the district, information of its existence in Sudharam, Begumganj, Ramganj and Lakhipur thanas having been obtained. In Begumganj thana the loss in 1910 was roughly estimated at 200,000 maunds of grain. Around Chaumuhani I was told that nearly half of the winter paddy was lost in 1911. From my own observations I should think this was an under- rather than an over-estimate. The disease is said to have been known in this neighbourhood for about 30 years. It began to increase some 20 years ago and to cause serious damage more recently. Several middle-aged men told me that it was unknown in their fathers' time and has much increased during the past six or eight years. This is perhaps as near as we can hope to get to its history.

In Tippera it is known to be prevalent near Chandpur, no doubt as a northward extension from Noakhali, and also around Comilla. The intervening area is probably more or less infected, especially as it is said to occur south of Laksam. The intensity of the disease is not known.

In Dacca, according to the District Gazetteer, considerable areas in the Madhupur jungle were destroyed in 1904 and 1905 "by a mysterious blight called *dak* which the villagers described as a vapour issuing from the ground but which appears to have been an obscure form of blight." Specimens of *dak* were first

sent to Pusa in 1911 and proved to be identical with the ufra of Noakhali and Tippera. In 1912 deep-water "aman" paddy was attacked by *dak* in the Narayanganj sub-division. The Mycological Collector of the Bengal Department of Agriculture, Babu A. L. Som, reported that the disease had been known for some ten years, but had only become serious within the past five years. It was said not to attack the "aus" crop. His collections showed that the attack was a typical and very severe one. Another large outbreak has been reported quite recently around Bikrampur and is said to extend to the west and north-west for a considerable distance towards the main stream of the Padma. It is certain that, as attention is directed to the pest by these enquiries, new localities will be revealed. It is not probable that these will represent areas of new infection. The evidence so far is that the disease spreads slowly, and apparent new extensions will be for the most part merely the result of more careful enquiries for some time to come. It is hoped to arrange for a survey of the infected tracts during the coming year. Those who know the means of communication available in the districts mentioned, during the paddy season, will appreciate the difficulties of this task.

It is obvious that the best methods to adopt in fighting this disease cannot be decided on in a few months. Experiments will have to be carried out within the affected area and, as in all crop experiments, may have to be repeated for several years before reliable results are obtained. Still, as the need is pressing, there are several measures which can be advised for immediate practice and some of these have been already recommended and are being tested by the cultivators themselves.

All the possible measures to be considered may be divided into those directed against the parasite and intended to lead to a reduction in its numbers, and those whose object is to render the host plant less susceptible to damage.

Into the first group fall all attempts to kill the parasite. It is, I think, useless to try any direct attack on it while it is actively swarming in the fields during the growth period of the

plant. Spraying a crop like paddy in India may be at once dismissed as impracticable. The addition of some vermicide to the water on the fields might be feasible were it not that the majority of the worms are out of reach of the water in the inner layers of the bud and towards the top of the plant. The cost of dealing with any large area would also probably be prohibitive. During the cold weather months, when the worms are inactive in the stubble and grain, direct attack is more hopeful. Success at this period will depend on several factors. There is, first, the ability to destroy any large proportion of the worms in a given crop. Secondly, destruction must be carried out over a sufficiently large area to prevent reinfection. With a motile organism and large movements, tidal and gravitational, of the surface water, the chances of reinfection will probably be considerable. There is, thirdly, a possibility that the disease will be found in some localities in the "boro" paddy, a crop which grows during the only months when active measures are feasible. This is, perhaps, not an important difficulty, as "boro" paddy is not as yet known to get the disease and is besides confined to certain well-defined tracts. It need not, for instance, enter into calculation at all in Noakhali District.

I believe that it will be found possible to reduce the parasite considerably by burning all the stubble left after the harvest of the winter rice. It may be necessary to supplement this by securing worm-free seed and by some cultural treatment of the soil. A certain proportion of the worms undoubtedly pass the early part of the period after harvest in the stubble. Others equally certainly go to the grain heaps through ears affected with *pucca* ufra. Whether any remain alive during this period in the soil is not yet certain. The evidence, so far as it goes, suggests that these last two lots of worms are not of great importance in renewing the disease. If the disease were commonly seed-borne, extension would probably have been much more rapid than has been the case, as exchange of seed from one locality to another goes on to some extent. If it were soil-borne, the soil of transplanted paddy fields would certainly have been infected long

ago, especially as it is the practice at the end of the cold weather to spread soil from the lowest land on to the fields intended for jute and from which a second crop of transplanted winter paddy will be taken. We know from the inoculations that these plants will get the disease if the parasite reaches them and we may, therefore, conclude that it is not present about the time of transplanting.

Some encouraging reports of the beneficial effects of burning the stubble have already been received, the recommendation to do so having been made last year by both Mr. Fletcher, Officiating Imperial Entomologist, and myself. The damage done by borers in the districts affected with ufra is such that Mr. Fletcher strongly advised burning the stubble as a regular agricultural routine. The practice is widespread in other parts of Bengal and should be introduced everywhere that ufra or serious damage by borers occurs.

Experiments on the effect of more thoroughly working the soil of the lower paddy fields than is customary are advisable, as even though the worm may not remain alive ordinarily in the soil, it is likely to be found in shed grain and fragments of stubble on the surface. By ploughing these in there is a prospect of their speedy decomposition and consequent death of the worm if, as the evidence suggests, it is unable to live long in moist soil. There are difficulties in the way, however, since much of the lower land gets very hard after harvest and has to be softened by the spring showers before the local cattle can plough it. Furthermore, the peculiar nitrogen relations of rice are such that there is a danger of causing a serious loss of nitrogen or the accumulation of poisonous nitrites by over-cultivation.

Should it be found that the use of infected seed is more dangerous than at present appears to be the case, steps will have to be taken to ensure a supply of healthy seed. This will require some organisation but should not be beyond the power of the local Department to undertake.

Into the second group of prophylactic measures fall all efforts to improve the health of the plant and to grow it under conditions

which will render it less liable to infection. The practice of transplanting should be encouraged wherever possible, owing to the observed freedom from ufra of the transplanted crop. It will probably be objected that transplantation on a larger scale than at present is not possible, owing to the nature of the annual inundation, but I am by no means satisfied that this is the case. The mere fact that the transplanted area near Begumganj has considerably increased in recent years, partly as a result of the extension of jute cultivation, is sufficient to disprove it. The people are already transplanting more than they did and would probably do so still more if urged. Transplanting is much more troublesome than broadcasting and the cultivators in Noakhali, as in certain other paddy tracts, are uncommonly lazy. In these matters influence counts for much and I think a good deal can be done towards increasing the transplanted area.

Liming the soil was tried, at the instance of the Bengal Department of Agriculture, in 1912. It appears to have had the effect of delaying the first appearance of the disease but not saving the crop. The cost is so high in Noakhali District as to make it doubtful if it can be used on a large scale.

The evidence, so far as it goes, appears to suggest that rice is more susceptible to ufra when it is grown under conditions which preclude the aeration of the soil throughout the greater part of the year. It is true that inoculations in fairly permeable soil succeeded at Pusa, but the attack was not so severe as is commonly met with in the submerged paddy fields near Begumganj. The growth of deep-water broadcasted paddy in a great deal of this area cannot be avoided, owing to the nature of the levels, but something might be done to promote drainage over considerable areas. The improvement of natural drainage in Lower Bengal has been prominently before Government for some time and any steps in this direction, in the districts affected with ufra, will probably help in reducing the losses caused by the disease.

A serious disease of rice is one of the greatest calamities that could befall the people in districts such as those referred to

above (where nearly three-quarters of the cultivated area is under paddy) for no other food crop can replace it. When, in addition, the disease is of a highly infectious nature, as the results of the inoculations show it to be in this case, the risk of spread to other areas is even a more important consideration than the losses caused within the infected area itself. On the one side is the whole of the enormous paddy area of Bengal; on the other, at a greater distance but joined by an almost continuous belt of paddy cultivation, is the Irrawaddy Delta, which supplies the bulk of the export rice of India. Were it certain that transplanted paddy would remain immune, the greater part of these areas might be regarded as not exposed to serious risk. But transplanted paddy has been artificially inoculated and it is not safe to rely on its apparent immunity. No reports of the disease having appeared west of the Brahmaputra have been received. The Irrawaddy Delta is also free from it, so far as I was able to determine during a recent tour in Burma, though several little known and comparatively unimportant rice diseases were found.

Rice is perhaps less subject to disease than any other important cereal. The appearance of a new disease of such intensity that the crop in many fields in the infected districts has been found not worth harvesting, is an occurrence that commands attention. In more advanced countries it is probable that a special staff would be deputed to secure an immediate thorough investigation. We have not yet reached the stage in India where this is possible, and the available staff has many other calls on its energies. The Government of Bengal have set aside Rs. 11,000 during the current year, for the trial on a large scale of measures calculated to check the disease. It is hoped shortly to obtain further information on some of the points which still remain obscure in the life-history of the parasite and the behaviour of the host plant to its attack. In collaboration with the Bengal Department, we shall then be in a position to fight it on more rational lines and with better prospect of success. At present our recommendations are more or less tentative and we

must await the results of the experiments which have been planned or are already in progress before undertaking the work on a scale commensurate with the importance of the subject.

THE WORLD'S CANE-SUGAR INDUSTRY.

A REVIEW.*

BY

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PART I.

Historical.

Attention has been attracted by the increase that has taken place in recent years in the production of sugar manufactured from sugar-cane, partly as the result of the altered politics of certain countries and colonies, and partly owing to the increased care paid to the business and scientific sides of cane cultivation and manufacture.

The following table will show the change from the time when cane-sugar was first threatened, and then in danger of being wiped out, by the competition of the privileged beet-sugar in the European market, to the present day, when cane-sugar is holding its own, and when a position of equilibrium has been established, that seems likely to last.

* This is a review of "The World's Cane-Sugar Industry, Past and Present" by H. C Prinsen Geerligs. Price 12/ (N. Rodger, Altrincham, Manchester).

TABLE I.

World's Production of Sugar excluding British India.

YEAR.	Tons. Beet-root Sugar.	Tons. Cane-Sugar.	Total production.
1859-60	451,584	1,340,980	1,792,564
1864-65	529,793	1,446,934	1,976,727
1869-70	846,422	1,740,793	2,587,215
1874-75	1,302,999	1,903,222	3,206,221
1880-81	1,820,734	2,027,052	3,847,786
1884-85	2,679,400	2,225,000	4,904,400
1889-90	3,536,700	2,138,000	5,674,700
1894-95	4,725,800	3,531,400	8,257,200
1899-00	5,410,900	2,880,900	8,291,800
1902-03	5,208,700	4,163,900	9,372,600
1904-05	4,870,000	4,776,000	9,646,000
1909-10	6,588,000	6,177,000	12,765,000
1911-12	6,801,000	6,548,000	13,349,000

Mr. Geerligs' book on the World's Cane-Sugar Industry, Past and Present, appearing at the moment when the industry has taken a new lease of life, is of great interest to both the technical and general reader; and of especial interest to India, which has from the remotest ages had an enormous acreage annually under cane.

Until recent times India has been singularly unmoved by the political and social commotions, that determined the location of the sugar-producing crops. Able to produce sufficient for its not extravagant needs, and even in times gone by to export, it went on its way unmoved: and it is now a matter for speculation whether the Indian people will put their house in order, and take advantage of the changed conditions to increase their out-turn of sugar to meet their expanding appetite for this article of diet, or leave the profits of doing so to other countries. Will

they grow their own sugar, or pay the enterprising inhabitants of Java, Mauritius, and probably Formosa and the Philippines, to do so for them ?

Anyone interested in this subject will be well repaid by reading Mr. Geerligs' work. The early history of sugar is told with great clearness and charm, and without the technological detail which, as a rule, tries the patience of the general reader.

Sugar-cane and a crude sugar made from it were found by the Crusaders on the shores of the Levant, whither it had been taken, probably from India, by the Saracens. It was introduced into Spain as early as 750 A.D., where, it may surprise many to learn, it still exists as an industry.

The growth of cane and manufacture of sugar, then a rare and highly appreciated delicacy in Europe, was extended and fostered by the Crusaders, and the semi-religious knighthoods established by them, wherever possible, and from the shores of the Mediterranean the sugar consumed by Mediæval Europe was procured.

The extension of the Turkish dominions, and the general break up of Mediæval Society threatened this source of supply, and caused the Portuguese and Spaniards to introduce it into their colonies of Madeira, the Azores, and West Africa, whence they supplied the sugar required by the European market.

The discovery of the new world, opening up an unrivalled field for human activity, provided a new home for the sugar-cane. Thither it was carried by the early voyagers, and flourished exceedingly on a fertile soil in a favoured climate. Fostered by the introduction of slaves and assigned labourers from Europe, the industry developed enormously, and sugar, from being a delicacy procurable only by the rich, became an article of universal consumption.

From the end of the 17th, during the 18th, and in the early part of the 19th century, the European colonies of the West Indies and the Americas were the main producers of the world's supply of sugar.

Their supply, inadequate to meet the increasing demands in the early days, was supplemented by imports of raw sugar by the Dutch and English East India Companies, but as the production of the colonies of the new world increased, this trade languished.

The rich West India Planter is a familiar figure in the literature of the period, but the days of unrivalled prosperity were not to go on for ever. Rumours of the abolition of slavery were in the air; and in the middle of the 18th century two events happened, which were destined ultimately to strike a fatal blow at the supremacy of the Cane Industry.

In 1776, a motion for the abolition of slavery was brought before the British Parliament; and in 1747 Maggraf communicated to the Royal Academy of Science and Literature in Berlin the discovery of a crystalline sugar in beet-root. The effect of neither of these events was, however, felt at the moment. The long-planned abolition of slavery did not become a settled fact in the British dominions until 1834, other European Colonies liberating their slaves a little later.

About 1840-1850, when the abolition of slavery had had its effect on the cane production, the manufacture of beet-sugar in Europe began to make great progress. Greatly favoured by the various continental governments, the process of manufacture had been improved, and more and more sugar was extracted from the beet. The industry was, moreover, enormously assisted financially by the system of levying the sugar excise on the raw material, and not on the finished product. The tax was settled on the assumption that a certain fixed quantity of sugar was extracted from the beet, but, with improvements in manufacture, this figure was soon exceeded.

The duty paid was returned on all sugar exported, and as this return of duty, or rebate, was calculated on the finished product, a manufacturer who exported all his sugar received back from the excise more than he actually paid, because he was extracting more sugar from the beet than the amount fixed as the basis of taxation, of the raw material.

This financial assistance did not matter much as long as the continental exports remained insignificant, but, when the competition of beet-sugar became acute in the seventies, it had the most detrimental effect on the Cane Industry. The unnaturally stimulating effect of the bounty system in Germany and Austria-Hungary, the two most successful beet-growing countries, led to an abnormal production of sugar. This the manufacturer exported to his great profit at the expense of the consumer in his own country, and when the crisis in the trade came, he did not pocket the whole of the premium he was receiving from his own tax-payer, but shared it with his customers in other countries, in order to get their custom, and if possible to secure complete control over the production, and stifle competition. In other words, beet-sugar was exported and sold under the cost of production.

The cane-growing countries were badly hit, particularly our own West Indian Colonies. The conditions of their labour market were far from settled or satisfactory. They had not begun, or in a few rare cases only just begun, to pay attention to scientific methods of cultivation and manufacture, and were not in a position to put up a good fight against so powerful a rival as the highly organised beet industry had become.

The production of beet-sugar went up by leaps and bounds until in the year 1899-1900, just before the Brussels Convention, 2/3 of the world's production of sugar (excluding British India) was made from beet.

The fact that cane-sugar did not entirely disappear in those cane countries which relied on Europe for their market, is due, Mr. Geerligs thinks, to the fact that the producers could think of nothing a little more profitable to grow in its place, so that they were obliged to struggle on, however hard-pressed they were, to make both ends meet.

Mr. Geerligs' statement of the attitude of Great Britain during this period is as follows :—

"The British consumers were greatly pleased with the existing state of affairs and did not think it wise to interfere for

the sake of their colonies. Great Britain, which was not a sugar-producing country, though a great consumer of sugar, was doubtless the very best market for sugar exported by the principal producing countries ; and, being compelled to dispose of their produce abroad, the exporters offered their goods to the British market even below cost price, just for the sake of the bounties held out to them. Owing to the rivalry among the continental producers, the British consumers, especially the preserve manufacturers, who were in the habit of using enormous quantities of sugar, got as much sugar as they wanted at a price at which it was impossible for them to produce it themselves. One can imagine that they wished this advantageous, though abnormal, condition to continue, and that they did not approve of measures put forward by their own government to put an end to the system for the sake of the West Indian colonists.

By the nineties, however most countries, concerned in paying them were getting heartily tired of the once approved bounties, and fervently wished to see them abolished. The British Government of the day, moreover, began to view with alarm the prospect of the total extinction of sugar production within its own dominions, and when the last Brussels Convention met in 1901, after attempts on the part of the representatives of the beet-growing countries to do their best for their own manufacturers, the balance was turned by Great Britain throwing in the weight of her influence against the bounty system, which was finally abolished by the signing of the Convention on March 5th, 1902, by the representatives of Germany, Austria, Belgium, Spain, France, Great Britain, Italy, The Netherlands, Sweden and Norway.

The subject of the Brussels Convention is too near the region of active politics to be further discussed in this article. It is however unquestionably the fact that the condition of the cane-growing countries has improved since the bounties were abolished. They are now able to hold their own, and appear likely to be able to do so in the future.

The Cane Industry, to quote Mr. Geerligs, "will not be able to oust the beet-root sugar manufacture, as an ever growing consumption draws on both kinds of sugar, and consequently gives both of them a chance to spread and flourish."

As will be seen by reference to Table I, the relative positions of the two industries are now about equal. The extent to which each will expand depends entirely on the ability displayed in the discovery and adoption of improved methods of cultivation and manufacture.

In the event, however, of another acute struggle, the Beet Industry will not find the cane countries unprepared, as they were in former times. Science has made its way to the tropics. The Biologist, the Chemist, and the Engineer, are at work in the cane fields and factories, applying modern methods of research to the problems of the Cane Industry.

Improved varieties are being created, tested, and distributed. Splendidly equipped Central Factories employing the best methods of milling, defecation, and evaporation, are making white sugar on the spot, and the old and wasteful processes are being abandoned. The yield of sugar per unit area is being increased almost everywhere except in India. As the author of the book under review puts it: "The Cane Industry knows far better how to turn to account any given area than it used to do before the crisis."

PART II.

Recent Development in different Countries.

The second part of his book Mr. Geerligs devotes to a detailed study of the position of the Cane Industry in various countries, and much valuable information, not hitherto easily obtained, is collected and arranged in a masterly manner.

Production was distributed amongst the more important cane-producing countries in 1910 as follows :—

India	2,125,000 tons.
Cuba	1,804,000 ,,
Java	1,278,000 ,,
South America and Mexico	708,000 ,,
Hawaii	463,000 ,,
United States...	335,000 ,,
Porto Rico	305,000 ,,
Mauritius	252,000 ,,
Formosa and Japan	270,000 ,,
West Indies	282,000 ,,
Australia	148,(00 ,,
Demerara	115,000 ,,
Philippines	112,000 ,,
Egypt	59,000 ,,

Java and Mauritius supply a large proportion of the white sugar imported into India, and are the competitors of the Central Factory in this country. A knowledge of the conditions of cultivation and manufacture in those islands is, therefore, of importance and value to the proprietors of Indian Factories.

The Sugar Industry in Formosa, Japan, and the Philippines, is on the point of great development, American capital is pouring into the latter country; and, owing to their geographical positions, they are all likely competitors of Java and Mauritius in the Indian market. If not in the immediate future, they are liable to become so at any time should the fiscal systems of the United States of America or Japan change; and a consideration of their possibilities is well worth study from an Indian point of view.

JAVA.

Java has been foremost among the cane countries to put their sugar industry on a sound business and scientific basis, and, thanks to this organisation, was able to take immediate advantage of the changed conditions in 1903, and has now outstripped all other countries as an exporter of white sugar to British India.

The following table gives the exports from Java and Mauritius to British India from 1894-95 to the present day, and shows the enormous increase that has taken place in the exports from the former country :—

TABLE II.

Exports of Sugar to British India.

Year.	From Java. Tons.	From Mauritius. Tons.
1894-95	7,692	......
1899-00	12,862	82,055
1904-05	96,622	76,382
1905-06	67,746	107,742
1906-07	149,929	133,767
1907-08	319,251	109,338
1908-09	312,662	126,129
1909-10	390,376	147,960
1910-11	445,621	136,472

Java possesses many natural advantages to mark it out as a successful cane-growing country—a rich alluvial soil, an equable temperature, and it is well watered by many rivers. The system of cane-growing resembles that in India in one respect, the cane is grown on land that is not the planter's property, but is rented by him for a single crop, or for a small number of years ; but it differs from the system in many parts of India in this detail, that the cultivation is under direct control, and supervised by the factory authorities.

The Dutch Government keeps a very careful eye on the cane cultivation, but the conditions and attitude of this government towards the colonies and their inhabitants, as well as the problems with which it has to deal, differ so widely from those in India that comparison is difficult.

The planting is exclusively done on irrigated land, and a triennial rotation of crops is practised. Mr. Geerligs gives the following as a typical scheme of cropping :—

September	Cane crop.
September to November	bean, maize, etc.
November to April	rice.
April to November	fallow, beans, indigo, etc.
November to April	rice.
April to September of the following year ...	cane.

The cane is planted in rows 4—5 feet apart, 1 foot deep and 1-1·5 feet wide. As the cultivation only allows one crop, and ratoons are unknown, every effort is made to secure a bumper one.

The crop is very generously manured. Manures supplying Nitrogen are almost exclusively used, chiefly Sulphate of Ammonia ; oil-cakes, such as castor, and cotton to a less extent. Potash and Phosphoric acid are seldom applied. The average expenditure on manures is put down at Rs. 35 per acre.

The following tables selected from statistics given on pages 128, 129, 134, 135, show the increase in area and production :—

TABLE III.

YEAR.	Yield of Sugar per acre. Tons (2,240 lbs.)
1840—44	0·809
1850—54	1·163
1860—64	1·499
1878	2·231
1883	2·920
1888	3·258

TABLE IV.

YEAR.	Area of cane planted. Acres	Yield of cane per acre in tons (2,240 lbs.)	Yield of sugar obtained per acre in tons (2,240 lbs.)	Yield of sugar from cane per cent.
1894-95	195,505	30·783	3·012	......
1899-00	220,440	33·937	3·249	9·57
1904-05	260,412	37·854	3·928	10·37
1909-10	314,335	39·033	4·033	10·33
1910-11	335,591	41·945	4·302	10·26

These figures are remarkable and everyone will feel that Mr. Geerligs is entitled to refer to them with pride. The

possibility of achieving such results is largely due to the work of the experiment stations, which were established in Java, when scientific assistance had to be called in to fight the *sereh* disease in the eighties, and which have since extended their scope into every department of sugar production.

The equipment and maintenance of Experimental Stations devoted to sugar research is, if one may so call it, a form of "Bounty" which leads to no international complications, and it is one that can give very effective assistance in building up a magnificent industry, as the Dutch in Java have proved.

The increase of production per acre seems to have been the result of (i) the knowledge that has been acquired of the manurial and cultural requirements of the soil, and the free use of imported artificial supplies of Nitrogen, and (ii) the discovery, propagation, and use, of new varieties, which can stand intensive culture, and give a large tonnage of cane, without suffering deterioration in the quality and purity of the juice.

New varieties of seedling canes, produced from seed by cross-fertilisation, have been raised in Java in large numbers, propagated by cuttings, and thoroughly tested at the Experimental Stations. By this means varieties have been obtained to suit all conditions, some ripening early, some late, some suitable for heavy soils, and some for light; in fact there is sufficient choice for each grower to choose the kind best suited to his conditions, and always have a supply of ripe fresh cane ready for the mills. The old varieties cultivated before the *sereh* disease made its appearance have been almost entirely replaced by the new and superior kinds.

This work is proceeding with undiminished vigour, and great hopes are entertained of raising the yield of sugar still higher.

The cost of production of cane in Java is a matter of interest to us in India, as many conflicting statements have been made on this subject. From the data given, the net cost of cane in the field amounts to $2\frac{1}{4}$ to 3 annas per maund, without cutting and

carting charges. This figure is not less than the cost in certain parts of Bihar and Gorakhpur, but is considerably less than it can be purchased for in Rohilkhand, and the sugar tract of the United Provinces, where $4\frac{1}{2}$—5 annas is not an uncommon price.

Mr. Geerligs prefaces his description of the manufacture of sugar in Java with the following remarks :—

"The manufacture of sugar from sugar-cane in Java has attained to great perfection, and may serve as an example of a well-managed and well-controlled business. The ample investment of funds in the newest machinery, the activity of the experiment sugar stations, the adequate training of sugar chemists and factory chiefs—all these have contributed towards making the Java sugar industry a model one of which it may rightly be proud."

The table given below, taken from the figures published by the Mutual Control of Java Factories certainly supports this statement :—

TABLE V.

Java Factory Results.

YEAR.	Sucrose on 100 parts cane.	Sucrose in juice on 100 parts cane.	Sucrose extracted in juice on 100 parts sucrose in cane.	SUCROSE OBTAINED ON 100 PARTS.			SUCROSE LOST ON 100 PARTS OF CANE IN			
				Cane.	Sucrose in cane.	Sucrose in juice.	Bagasse.	Filter cake.	Molasses & undetermined.	TOTAL.
1900	12·26	11·04	90·1	9·62	78·53	87·15	1·22	0·10	1·32	2·64
1905	12·66	11·54	91·2	10·33	81·69	89·51	1·12	0·09	1·12	2·33
1910	12·54	11·43	91·2	10·26	81·82	89·76	1·11	0·10	1·07	2·28

The yields of sugar from cane are given in detail for the different residencies for 15 years on page 132. The averages for

the whole island during the years 1900, 1905 and 1910 were as follows :—

1900	... ...	9·57 per cent. sugar in cane.
1905	... ...	10·37 ,, ,,
1910	... ...	10·33 ,, ,,

In these statistics the yield of sugar is calculated by taking the quantity of first sugar and second sugar for the full weight, to which is added half the weight of the black stroop or sack sugar. If on 100 canes 8·39 per cent. white sugar, 0·37 per cent. refining crystals, 1·80 per cent. second sugar, and 0·38 per cent. black stroop, are yielded, the *rendement* is calculated as follows :—

White sugar	8·39	= 8·39
Refining crystals	0·37	= 0·37
Second sugar	1·80	= 1·80
Black stroop	0·38 ÷ 2	= 0·19
Total rendement ...		10·75

The kinds of sugar shipped from Java during the years 1900, 1905, 1910, are shown in the following table :—

TABLE VI.

KIND OF SUGAR.	1900.	1905.	1910.
Sack Sugar	4·7	4·4	3·1
12-14 D. S. (Polar. 96·5)	81·8	74·2	31·8
15-17 D. S. (Polar. 98·0)	11·1	10·3	30·2
18-20 D. S. and higher (sold according to sample) ...	1·9	1·2	...
Superior white sugar	·5	8·5	34·9
TOTAL	100·0	100·0	100·0

From this it appears that the Java Factories are producing year by year a finer quality sugar. In fact by studying the full table given by Mr. Geerligs on page 137, from which these

figures are taken, it will be seen that the kind of sugar has always changed rapidly to meet the requirement of fresh markets.

The prime cost of sugar in Java is given for 11-13 D. S.,—a moist, dark coloured, well crystallised, sugar polarising at 96·5—as Rs. 4-2-0 per maund. The cost of producing superior white sugar is 7·2 annas per maund, and for 18-20 D. S. 3·6 annas per maund more. The cost of producing the different grades of sugar thus works out to the following, including all expenses except interest on capital :—

Superior, White	...	... Rs. 4-9-2 per maund.
18-20 D. S.	...	... ,, 4-5-6 ,, ,,
11-13 D. S. (Pol. 96·5)...		... ,, 4-2-0 ,, ,,

Other figures are given for 11-13 D. S., varying from Rs. 4-2-0 to Rs. 4-7-0 per maund, but Mr. Geerligs thinks that those first quoted are the best.

The yield of sugar per 100 of cane for a succession of years. 1899-1910, averages over 10, from canes varying from 13·9 to 12·1 per cent. sucrose. The average efficiency factor for this period is 81·1. That is, from every 100 parts sugar in the cane 81·1 parts of sucrose are recovered. Such good work is no doubt in a large measure the result of the constant and high purity of the juice produced under the settled conditions of the Javan climate.

Comparison with Upper India.

In Upper India the indigenous canes vary to a much greater extent than is generally supposed to be the case, and are much affected by annual weather disturbances. One year they will be ripe and pure as the result of a well regulated monsoon. in another year the percentage of sugar will be considerably lower, and, what is more important, the purity may be so low as to render efficient factory work difficult. The actual percentage of sugar, and the yield of cane per acre of the indigenous varieties. as ordinarily grown by the cultivators, are also figures of an entirely different order to those obtained in Java. These facts

should be borne in mind when comparing the Javan results and prices with those obtained in India.

For instance in a district in the Eastern parts of the United Provinces in 1911 the average per cent. of sucrose in cane in 19 indigenous varieties under experiment was 10·4. In 1912, when the monsoon had been irregular in those parts, the percentage of sucrose in the same varieties was 8·28, while in the Western districts, where good conditions had obtained, 11·0 to 12·0 per cent. was not uncommon. The sugar factory is only extracting sugar from cane—it is not synthesising it from other materials, so that, however good the factory work may be, the outturn is conditioned by the quality of the raw materials at its disposal. If a factory in the Eastern districts, where the cane contained in 1911, 10·4 per cent., and in 1912, 8·28 per cent. sucrose, had been working at the high Javan efficiency given above, it could not have recovered more than 8·4 per cent. sucrose on cane in 1911, and 6·7 per cent. in 1912, while one in the Western districts could not have recovered more than 8·9—9·7 per cent.

The efficiency of large factories at work in India compares favourably with those of other countries, but it cannot be conceded, that the raw material, they have to work with, is of the same quality. The indigenous *ukh* and *ganna* varieties commonly grown, contain from 9 to 11 per cent. of sugar, varying with the season. The quality and amount of fibre is such that high extraction is by no means such an easy matter as it is with varieties like Rose Bamboo and the thick Mauritius ones.

Even where it is found that large factories can be worked with the present canes, it cannot be denied that the problem of producing white sugar, and competing with other countries, will be much easier to solve, if (i) the outturn of sugar per unit area is increased by improving and intensifying the cultivation, and (ii) if better varieties are selected with reference both to their actual sucrose content, and their workability in the factory. The writer of this review confidently believes such improvements to be possible, though they may be slowly achieved.

There is no reason why varieties should not be selected, comparing in quality with the best grown anywhere, where irrigation facilities exist. As an instance a Mauritius variety, Ashy Mauritius, may be quoted. This variety was selected from a number of imported varieties, and has been grown for some years under the best and most intensive cultivation possible. Last year it yielded under these conditions 30 tons of cane, and 101 maunds of *gur* per acre, and contained 13·05 per cent. sucrose in the canes. The local *ukh* varieties, such as *Kewahi* and *Saurati*, were only giving 30—40 maunds of *gur* per acre.

There is no reason to suppose that Java has reached the limit of its productive capacity, either as regards outturn, or acreage under cane. Wherever possible, land is being taken up, and brought under cane cultivation ; as already pointed out, the production of new varieties is proceeding apace, and careful attention to the best Agricultural methods shows no signs of diminishing.

Mauritius.

Mauritius is a considerable contributor to the imports of sugar into British India, and has this additional interest, that the field and factory work is done by Indian labourers, and that much of the cane used by the factories is grown by the thrifty Indian immigrants, who settled in the island as independent cultivators, when many of the large estates were broken up. In fact owing to the taste for emigration from India to Mauritius, that developed at an early date, the labour question there has never been acute, and this permanent complaint of most cane countries is absent.

The Mauritians, however, appear to suffer from some special complaints of their own, chiefly shortage of water, lack of irrigation facilities to use such as they do possess, and the periodic visits of cyclones, as well as cane and cattle disease. Both the large and small planters seem also to be chronic sufferers from scarcity of ready money, and their position in this respect does not seem to have been improved by the financial system of advances, that has come along with the highly appreciated Indian

immigrant. So far as one is able to judge, the Mahajan, in many guises, is very busy there.

Notwithstanding these drawbacks sugar is the one industry of the island—87 per cent. of the cultivated land is devoted to it, and the acreage and outturn has been approximately constant for some years.

The system of cane planting is interesting. The cane is planted in holes 3 feet apart in rows 3 to 4 feet from each other, and artificial manure is applied, after germination, in the form of Sulphate of Ammonia, Superphosphate, and Potash, to which dung is added afterwards if available. The growing period is 2 years in the cold regions, 18 to 20 months in the temperate zone, and little over a year in the warmer tracts, 1st, 2nd, and 3rd ratoons are taken.

Mauritius possesses several varieties of cane containing a high percentage of sucrose, 15·13—13·13 per cent. are quoted as maximum and minimum figures, and they yield a pure juice. These were introduced from various sources, Java, Trinidad, British Guiana, Queensland and Hawaii, when the older varieties began to deteriorate. The yield per acre is 2½ tons raw sugar on the larger plantations, and 1½ tons on the smaller ones cultivated by Indians.

The raw material used by the Mauritius factory is excellent, and that doubtless has enabled them to do such good factory work, and encouraged the improvement in machinery, which appears to have been general.

The yield of sugar per 100 canes is high, as we should expect it to be, and the efficiency of the factories is increasing.

The following figures give an approximate idea of the working of the Mauritius factories :—

TABLE VII.

YEAR.	Yield on 100 cane. (Basis 96·0).	Yield on 100 sucrose in cane.
1905-06 ...	10·00	74·1
1907-08 ...	10·41	77·1
1909-10 ...	10·56	78·3
1910-11 ...	10·63	78·5

The cane, where it is not grown by the factories themselves, is purchased in two ways :--

(i) From the large planter, who receives 6·5 to 7 per cent. of the weight of cane delivered at the factory in sugar, or the money equivalent at the current rates ; this amounts to 5·8 to 6·2 annas per maund, when the market price of sugar is Rs. 5-9-0 per maund.

(ii) It is bought directly from the Indian cultivator, who gets cash down, delivered at the factory, varying from 4·7 annas to 6·2 annas per maund, the average being 5 annas per maund.

The cost of production in Mauritius, worked out into rupees per maund, is given as follows :—

TABLE VIII.

Year.	Cost of production per maund. (Basis 96·0) Rs.	As.
1904	5	0
1905	4	6
1906	4	2
1907	4	8

FORMOSA.

The Formosan Sugar Industry is of interest for two reasons :—

(i) The possibility of its becoming a large contributor to the Indian market, when its production is allowed to exceed the internal requirements of the Japanese Empire.

(ii) The strong measures that have been taken by the Japanese Government to extend sugar manufacture and cultivation, and the effect they have had in the short period of 10 years in laying the foundation of a gigantic industry.

Although Formosa became part of the Japanese Empire in 1895 at the conclusion of the Chino-Japanese war, it was not until 1900 that the development of the country could be taken in hand seriously by the new owners. One of the first things to receive their attention was the sugar industry, already important but in a very backward state both as regards cultivation and manufacture. In 1902, a Sugar Bureau was established to deal with all questions of sugar production, and this organisation at once began a vigorous campaign. Japanese students were sent to Java and Hawaii to try to learn the best methods employed there, and efforts were at once made to replace the two very inferior varieties of cane that Formosa possessed at the time, by varieties possessing a higher sugar content. The well-known canes of every country were imported, and severely tested at the experiment stations in many parts of the island, in the hope of finding one suited to Formosan conditions. Hawaii, Java, Mauritius, and the West Indies, all contributed their best varieties and seedlings ; and the Sugar Bureau have had no difficulty, apparently, in deciding that *Rose Bamboo*, obtained from Hawaii, is the ideal cane for Formosa.

Having decided on this, measures were taken to extend its cultivation. Wherever it was planted, manure to the value of Rs. 12 per acre was provided free by Government, on condition that growers expended Rs. 16 per acre for the same purpose. At the present time, 75 per cent. of the area devoted to cane is under this variety. The outturn per acre has been increased from 8 tons of cane with a yield of 6 per cent. of inferior raw sugar, given by the indigenous varieties, to 14 tons cane per acre with a yield of 11 per cent. centrifugalled sugar where *Rose Bamboo* has been taken up.

This extension was not, however, due to educational propaganda alone. The Sugar Bureau, when they had reason to

believe that the reforms and improvements suggested by them were not meeting with ready response at the hands of the cane growers, passed an ordinance in 1905, which included amongst its terms the following :—

(i) No sugar factory can be started without the sanction of the Director of the Sugar Bureau.

(ii) The area within which cane can be purchased by any factory is defined, and another factory cannot be started in that area.

(iii) Cane grown in the defined area must be sold to the factory, and not exported to another area.

(iv) The factory is bound to buy all the cane grown in its area whether it needs it or not, but growers are under no compulsion to plant cane.

(v) Cane cannot be crushed in small bullock mills without permission, which is not freely given.

Sugar became a licensed trade in Formosa as a result of these regulations; and £2,500,000 already paid up capital is invested in the production of sugar by modern methods. There are 29 big factories at work, crushing from 500 to 1,000 tons of cane a day.

The price paid for cane has not gone down. Cultivators, as pointed out, are not compelled to plant cane, but if they do, they must sell it to certain factories. The price, moreover, has to be approved by Government. The price of cane at present works out to about 4½ annas per maund delivered at the factory. The cost price of sugar at the factory is Rs. 4-8½ per maund. The sugar produced appears to be a fine grained moist sugar made specially to meet the requirements of the Japanese market, but with the modern plant possessed by the factories they could produce any kind of sugar.

Details of the working of a single Formosa Sugar Factory taken from a paper* on the Formosan Sugar Industry are given below.

* The Formosa Sugar Industry, by T. Murakami, I.S.J., March 1913, p. 120.

TABLE IX.

YEAR.	Sucrose on 100 parts cane.	Sucrose in juice on 100 parts cane.	Sucrose extracted in juice on 100 parts sucrose in cane.	SUCROSE OBTAINED IN 100 PARTS.			SUCROSE LOST ON 100 PARTS CANE IN			TOTAL.
				Cane.	Sucrose in cane.	Sucrose in juice.	Bagasse.	Filter cake.	Molasses and undetermined.	
1908-09 ...	13·9	12·16	87·5	10·61	76·3	87·2	1·74	·18	1·55	3·47
1909-10 ...	13·4	12·28	91·7	10·7	80·0	87·1	1·00	·11	1·58	2·39
1910-11 ...	13·1	11·97	91·4	10·23	83·0	90·0	1·13	·11	1·74	2 98

This shows an exceedingly high state of efficiency, as high, in fact, as given in Mr. Geerligs' book for the Javan results.

The actual amount of raw sugar produced during this period is given as follows :—

1908-09	... ...	11·22 per cent. on cane.
1909-10	... ...	11·38 ,, ,,
1910-11	... ...	10·88 ,, ,,

An idea of the increase in the Formosan Industry can be gathered from the exports, which are as follows :—

1901-02	... ...	46,893 tons
1904-05	... ...	49,565 ,,
1907-08	... ...	68,450 ,,
1908-09	... ...	122,000 ,,
1909-10	... ...	160,000 ,,
1910-11	... ...	256,950 ,,

Mr. Geerligs points out that the success of the Formosan Industry is due to the powerful patronage of the Japanese Government, and that whether the export to foreign countries develops depends entirely on the inland politics of Japan. With our past experience of what bounty-fed sugar can do in

the way of cheap exports, the situation is worth careful watching from the point of view of the Indian market.

Philippines.

The sugar industry of the Philippines is of interest mainly on account of its possibilities in the near future, when American capital and enterprise have had time to develop the natural advantages that these islands possess for cane cultivation. The extent of the latter may be judged from the fact that, in spite of primitive methods of cultivation and extraction, and an open pan system of evaporation, the industry has always been considerable. In 1911, 207,219 tons of a low grade sugar (Polar 89·0) were produced, and exported at a profit.

When attention is paid to improving the cultivation and quality of the cane, and when the old methods of manufacture are replaced by modern ones, it is easy to imagine that a great development may take place.

Encouraged by the protection of the United States, American capitalists have turned their attention to the Philippines. In 1909, 50,000 acres were secured by American Sugar Syndicates in Mindoro, and more recently 20,000 have been taken for sugar cultivation by Hawaiian planters in another island.

How far the progress of the Sugar Industry will be influenced by the new American Tariff it is difficult to say, but, should it be anything like that indicated, it is reasonable to suppose that the Indian market will receive attention. Mr. Geerligs' remarks on the future of the industry in the Philippines are significant. He says: "It may have in the end a future such as we dare not put down in words."

General.

Most valuable and interesting information from different countries is given on the following points :—

(i) The price of cane.
(ii) The outturn of sugar per 100 cane.
(iii) The yield of sugar per acre.

Some of these results have been selected, and summarised in the following table :—

TABLE X.

Country.	Price of cane delivered at factory, annas per maund.	Yield of sugar per 100 cane (Basis 96 Polar.)	Sucrose per 100 cane.	Yield of raw sugar per acre in maunds.
Cuba ...	4·4	11·62	12·13	53·5
Hawaii ...	5·8	12·50	15·8—17·8	127·5
Australia ...	6·0	10·95	12·13	51·6
Brazil ...	4-6·5	9·0	15·0	54·4
		(5-6 open pan)		
Egypt ...	5·5	10·71	12·73	58·0
Barbados ...	......	7·5 (Muscovado)	13·5	......
Trinidad ...	......	8·94	12·5	......
British Guiana ...	3·0	8·4	11·5	......

It will be noticed that the price of cane in Cuba is not high in spite of the scarcity of labour. This is accounted for by the fact that cane, when once planted, yields a large number of ratoon crops (five or even more). The price in Hawaii is high due to labour difficulties, which seem to be more prominent here than in most countries. Indentured labour is of course forbidden by the United States, and white labour finds it hard to stand the strain of field work under tropical conditions. Everything has been tried; Portuguese, Japanese, Russians from Vladivostock—but the labour question is still the limiting factor in Hawaiian production.

The scarcity and high price of labour is compensated, to some extent, by the high outturn of sugar per acre, and the efficiency with which the factories are worked. The sugar content of the bagasse is reduced to 3 per cent., and the extraction of sugar per

100 sugar in the cane reaches 95 per cent. This result is produced by maceration to an extent which would not be profitable in a country like India, where labour is plentiful and fuel scarce. The yield of raw sugar per acre in Hawaii also exceeds that of any other country. The average for 1910 over the whole island was over 4½ tons ; while on selected estates it was as high as 8·8 tons. Careful attention is given to cultivation and the selection of suitable varieties, and the cane fields are intensely manured. The amount spent on artificial manures (Sulphate of Ammonia, Saltpetre, Potash and Superphosphate) is given as Rs. 60 per acre.

No cane-growing country has been overlooked by Mr. Geerligs ; from Cuba, with its two million tons, to Tahiti in the Society Islands, with an annual production of 400—500 tons. The information obtainable is naturally more complete in some countries than in others, and most complete of all where systems of mutual control have been established.

If it is permissible to offer a suggestion for the improvement of so excellent a volume, it might be said that, in a new edition, a little more information with regard to the working of the central factory system in the West Indies would be welcome to East Indian readers.

SOME IMPROVEMENTS IN THE PACKING AND TRANSPORT OF FRUIT IN INDIA.

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I.—Introduction.

In this paper it is proposed to deal briefly with the packing and transport of fruit in India, and to draw attention to some of the improvements which can be made, at once, in the present methods of dealing with this trade. In several tracts of India, particularly on the Western Frontier, excellent fruit can be produced ; while in large cities, like Calcutta, Bombay, and Delhi, markets exist for the produce. In addition to the large towns and Military cantonments, a number of European and Indian consumers are to be found, scattered through the country, who are ready to purchase fruit, provided it is good, fairly cheap, and properly packed.

The general conditions under which fruit is grown and transported in India must be borne in mind. The methods of production are primitive compared with those of other countries in which cultivation has been taken up on modern lines. The crops obtained by the people per unit of area fall below what is easily

possible, both in quantity and quality. This result, in a vegetarian country, can only arise from a low standard of agriculture. The packing and transport of the produce to the railway are equally primitive. In consequence, a great deal of loss and damage occur in transit, and the distance to which fruit can be sent by the present methods is comparatively short, especially as most of the produce has to be carried through hot regions where the humidity is frequently very high. These causes seriously limit the market open to any fruit tract, and diminish the number of possible customers.

In the production and transport of fruit in India great improvements can be made. Experience in the plains, at Pusa in Bihar, and at Quetta on the Western Frontier, not only in the cultivation but also in the packing and transport of fruit, has shown quite clearly what an enormous amount of progress is possible. The results already obtained prove that it is neither the soil or climate, nor the varieties grown, that are at fault, but that the poor results obtained by the people are the direct consequences of the primitive methods of agriculture in vogue. It is sometimes thought that little or nothing can be done to develop the Indian fruit trade unless the Railway Companies construct refrigerator cars, and until cold storage facilities at the large markets are provided. Experience indicates that a great field for development is open without these expensive means of transport and storage, and that the road to success lies rather in the direction of better methods of production and packing.

II.—The Present Methods of Packing Fruit.

In order to appreciate the present condition of the Indian fruit trade, it is necessary to follow the produce from the garden to the market.

There is a great similarity, in different tracts, in the methods of picking fruit for market. In order to withstand the rough handling experienced at all stages in the processes of marketing, fruit, of all kinds, is always picked green and unripe, and at a stage when the full development of flavour is impossible. The

want of attention to pruning, and the close planting of the trees, render the damage in picking much greater than would be the case in modern fruit gardens, where dwarf trees are the rule. The crop is often shaken off the branches, either into sheets or else on to the ground. A good deal more bruising takes place when the fruit is heaped up before packing. Padded trays for picking are unknown, and the grading and packing are done on the ground, generally under the shade of a tree. There are no packing sheds, and no padded packing tables—possibly on account of the national custom, of working, as far as possible, on the ground.

The packages used for fruit, even for such delicate produce as grapes and peaches, are for the most part ill adapted for the purpose. Old kerosine oil boxes represent the rigid type of fruit box, while wicker baskets of various sizes and shapes are common. There is a general absence of ventilation, in all the packages—a circumstance which probably follows from the necessity of covering in the fruit to prevent theft. The packing material used is often unsuitable, grass and leaves being commonly employed; these give off water and do not absorb the moisture transpired by the fruit; in consequence, fermentation and decay are hastened. The flavour is often harmed by the want of ventilation, and the fruit sometimes becomes tainted. There are other disadvantages from the packages used; the upper layers of fruit press on the lower and a good deal of crushing and bruising take place; the packages are often non-rigid and are crushed out of shape, in transit, by the weight of others above them. Good examples of this crushing are to be seen on the Jhelum valley road in September when the Kashmir apple crop is on the way to the Indian market.

The facilities for carrying fruit on some of the Indian railways are excellent. Well ventilated fruit vans, constructed to run on the mail trains, are in use on the North-Western Railway and also on the East Indian system. The North-Western vans are provided with shelves, and through cars are provided on certain sections of the line. The material carried by these vans,

however, leaves much to be desired. The fruit is often spoiled, or at least greatly damaged, before it is loaded on to the trains; the packages are of all shapes, sizes, and weights, and there is a great deal of loss of shelf room and van space. The circular wicker packages are bound to rock in transit, and some shifting is bound to take place on steep gradients, and round curves. Some of the wicker baskets are too heavy for the coolies to lift easily, and these are often rolled out of the vans, on to the platforms, at large junctions where the contents of the vans have to be distributed.

In the markets themselves a good deal of further damage results, although most of the large cities provide roofed-in markets and numerous fruit stalls. The national custom, of doing everything on the floor, again asserts itself and, before the contents of the fruit packages are displayed for sale, a preliminary sorting over, on the ground, to remove the worst casualties, is a common spectacle. The sale of fruit is usually by weight, and in this process and in the subsequent transport to the table, often by means of a *jharan* (duster), the last series of bruises are inflicted. There is little wonder, therefore, that the final product presents a battered and bruised appearance, and that good fruit is so rarely seen in India.

III.—Experiments on the Packing of Fruit in India.

A considerable amount of attention has been paid to the packing of fruit under Indian conditions, both at Pusa in Bihar and also at Quetta. These experiments were originally started in 1908, at Pusa, and have been continued since, as opportunity offered, particularly at Quetta during the summers of 1911 and 1912.

Bamboo peach baskets.

The first of these experiments related to the packing of Bihar peaches, in 1908 and 1909. In this tract, peaches ripen towards the end of May and the beginning of June, when both the day and night temperatures are high. The air is frequently

damp at this time, so that the conditions for transporting such delicate produce as peaches are particularly exacting. In 1909, a method of packing was devised and tested, by which practically ripe peaches could withstand a journey of 72 hours on the railway, without deterioration, when booked in the ordinary way. Local materials and labour, only, were used in the work, and no artificial cooling was employed at any stage. The packages adopted were round, flat-bottomed, bamboo baskets, about $5\frac{1}{2}$ inches high, fitted with flat lids. Into these, two tiers of small, circular, bamboo cells, for the single selected peaches, were fitted; the two tiers being separated by a flat, circular, open-work, bamboo partition which could be dropped into the basket to serve as a floor for the second tier of cups (Fig. 1). The lid, when wired on, served to secure the upper tier, and also to keep the whole basket, and its contents, rigid. Theft was prevented by sealing the wire by means of a lead seal, in the manner adopted in the Kulu apple baskets when sent by parcel post. Each basket contained about 25 bamboo cups, and thus served to carry that number of peaches. These baskets were made by the local *domes*, for four annas each. If required in large numbers the contract price would be considerably less than this.

FIG. 1.—BAMBOO PEACH BASKETS.

Picking is best done at daybreak, as at this time the temperature is near the minimum, and the peaches are relatively cool. They are best picked, one layer deep, into trays or baskets padded with *san*, and the wrapping in thin blue paper is done on

padded tables in the plot. A little *san* fibre, covered with gunny, provides a good padding on a table for packing purposes. Only the best peaches are selected, which, after wrapping, are packed into the cells, with a little *san* fibre to prevent shaking and bruising during transit. The *san* should be wrapped round each fruit, and the whole should fit well into the cell, without any shaking. The paper and *san* fibre, besides, absorb part of the moisture given off by the peaches during the journey, while the openwork nature of the package promotes ventilation. Other materials for packing, besides *san*, were tried, such as peat, cotton wool and wood wool. None of these proved so cheap or so resilient as *san*. Sent in this manner, peaches reached Simla in excellent condition, and withstood the journey of three days. This transport involved a journey of seven miles in a bullock cart to the railway, the crossing of the Ganges in a ferry steamer, and eight changes between the garden and destination. Attention is drawn to these results as they show what can be done in India in the transport of fruit, with no other materials and labour than are available, and without the use of ice cars. All that is necessary is proper care in picking and packing and the use of suitable baskets. Some difficulty is always experienced in training the local labour to pick properly and to take sufficient care in handling the fruit. Boys are best for this work, and after a time they learn to judge the right stage at which peaches should be picked. Their general tendency is to pick when much too unripe.

Venesta-wood fruit boxes.

The next step in the fruit packing experiments consisted in the trial of returnable fruit boxes at Quetta, in 1911. This work was undertaken after seeing the way in which the fruit vans were loaded at Quetta. These ventilated cars have been constructed so as to run at high speeds, and can be attached to the mail trains. The fruit is carried mainly on shelves running down the sides of the van, and the miscellaneous packages, all shapes and sizes, which are placed on these, involve a vast loss of carrying

capacity, and lead to a good deal of movement in transit. It appeared that if a returnable outer package, constructed to fit the shelves, could be devised, this loss of shelf room could be avoided. This was pointed out to the Local Administration in 1909, and some correspondence on the subject ensued between the Political Officers at Quetta and the North-Western Railway Company. The result was that a concession was obtained, by which the senders of fruit boxes of standard size were granted the free return of empties on the North-Western system. Accordingly, a returnable fruit box, made of venesta wood and fitted with cells made of the leaves of a dwarf palm known as *pish* (*Nannorhops Ritchieana*) found growing in the lower valleys of Baluchistan, was, in 1910, modelled on the bamboo peach baskets by Captain Keyes, I.A., then Assistant Political Agent at Quetta. A number of these boxes were tried in 1911, one of the objects of the experiments being to see how far returnable fruit packages could be used with success under Indian conditions. These returnable venesta boxes with *pish* cells did not prove successful, and were not taken up by the local fruit merchants. The *pish* cells were very irregular in size and, in consequence, the labour of packing was considerable. They were uneven in shape and size, and had no reference either to the size of a peach or to the dimensions of the boxes. A large amount of time was therefore wasted in adapting these cups to the purpose in view ; although they appeared to be cheap, in reality they were very dear, on account of the extra time and labour in packing and the large number that had to be thrown away. The frequent contraction of the rim of these units rendered the removal of the peaches on arrival a difficult matter. Further, the venesta boxes were not rigid enough and when filled with peaches the sides bulged and so the sliding lids were difficult to adjust—moreover, there were no floors to separate the different layers. The boxes, when filled, usually weighed from fourteen to fifteen seers, and thus came midway between the ten and twenty seer rates ; each box was therefore charged for as twenty seers. These disadvantages were small, however, compared with the mistakes and overcharges

made by distant Railway Companies when the empty boxes were returned to Quetta. Frequently they were charged for at full parcel rates, the charges sometimes being equal to the first cost of the boxes. The only remedy for these mistakes was to pay the charges and then to file a claim. Our experiences with these boxes in 1911 showed that, under the present railway rules, any merchant sending large numbers of returnable packages on the Indian railways would have to keep at least one extra clerk to file claims and to conduct the additional correspondence that would ensue with the Railway Company.

Non-returnable fruit packages.

In 1912, it was decided to work largely in the direction of light, non-returnable packages, and to avoid altogether the difficulties connected with the return of empties. In these investigations the observations and enquiries made while on deputation in England in 1910, on the methods of packing and transporting fruit to the London market, were of considerable assistance. Attention was paid not only to the British fruit trade, but also to the manner in which fruit is sent from the Continent and other countries to the Home markets. It was found that there was a growing tendency, in Great Britain, to copy the cheap non-returnable gift packages, of the Climax type, now such a feature of fruit transport in the United States. These are made chiefly of *chip* and are exceedingly light, cheap, and attractive ; particularly for delicate fruit such as strawberries. Arrangements were at once made with the British Basket Co. of Glasgow, the manufacturers of these packages in Great Britain, to import a number for trial at Quetta under Indian conditions. It was soon discovered, however, that these boxes, although sound in principle, were quite unsuited to India, on account of the railway rules in force, by which each package is charged for, separately, according to a scale of weights. For example, any package between ten and twenty seers is charged as twenty seers. It was evident that the packages would have to be made to fit the rates, and accordingly all those likely to be

of use were redesigned. A number of each were made to order for the Quetta experiments, and in this a large amount of valuable assistance was given by the manufacturers. After some preliminary trials in 1911, the following packages were designed, which were again tested in 1912 and then put on the market at Quetta :—

1. Peach crates, with chip compartments, to come under the five-seer rate.
2. Grape boxes for small consignments.
3. Various forms of Climax baskets for local use.
4. Non-returnable crates for the wholesale trade.
5. Returnable crates, for short journeys on the North-Western Railway and for carrying fruit on camels.

Peach crates.—There is a market, in Baluchistan, for a light, non-returnable, fruit crate, suitable for choice peaches and nectarines, which would come under the five-seer rate. Two crates, each weighing 1 seer 2 chittacks, were designed for this purpose, one to take fifteen large peaches, the other to take twenty medium sized fruits. The principle in each was the same, namely, the provision of a separate chip compartment, with a lid, for each peach—the whole to be carried in a light, ventilated crate. Three and a half inch cube compartments were used for the fifteen size, while three-inch cubes were employed for the crate with twenty compartments. The separate compartments are made of chip, which is prepared at Glasgow for bending into the cubes, and packed flat in suitable lengths for transport to India. Each cube is made of two pieces of chip, and these can be sewed together either by means of a wire stitching machine worked by the feet or by a hand automatic stapling press such as is used for fastening papers. The peach crates are packed in the same way as the bamboo cells of the Pusa peach baskets. Each selected peach is wrapped in thin paper, and then in a little *san* fibre—the whole being placed in the compartment so that there is no movement in any direction. The upper laths are then nailed on, and the crates secured by means of string or wire and sealed with a lead seal, in the manner indicated in

Fig. 2. In securing with string it is best to cut a small groove at the corners, so as to prevent slipping.

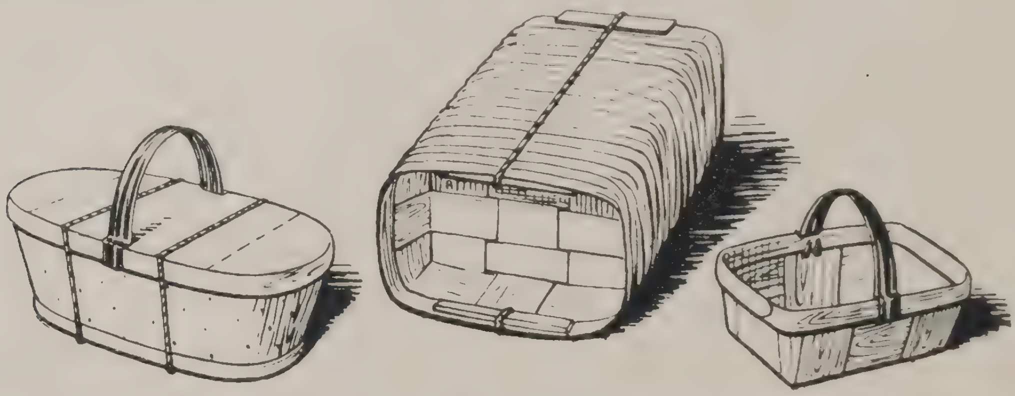

FIG. 2.—PEACH CRATES USED AT QUETTA IN 1912.

One great advantage of these peach crates should be noticed. The compartments are machine-made, and fit the outer crate accurately. As they are square, and not round, packing is facilitated, and the time taken in the work is shortened. This uniformity in machine-made units will always be a great advantage over locally made round cells of *pish*, or bamboo, which never quite fit. These peach crates are exceedingly strong, and bear railway transport without damage. About 1,200 of these packages were sold at Quetta in 1912, largely to Indian fruit merchants. They were put on the market complete, including *san* fibre, wrapping paper, and a sheet of printed directions in Urdu and English—and were sold at nine annas each.

2. *Grape boxes.*—It was proposed to try experiments in 1912, at Quetta, with small wooden grape boxes—using cork dust as the packing material. The cork dust, however, did not arrive in time and the original experiments could not be carried out. The boxes were however tried, with *san* fibre as packing material, and proved successful—the complete stock of the larger size, which measured $15 \times 7 \times 4\frac{3}{4}$ inches and which weighed 10 chittaks each, being sold at once. When packed for long distances the bunches of grapes should be wrapped in thin paper and packed a little time after picking, so as to allow the stalks to wither. The packing must be rigid, and this is possible by the use of *san* fibre. These grape boxes are clean and light and, where wood is

scarce and labour dear, as at Quetta, can be put on the market cheaper than locally made boxes. The original experiments—using cork dust as a packing material—will be carried out next year. These grape boxes were sold retail at Quetta at three annas and a half each.

3. *Climax baskets.*—In order to supply cheap fruit baskets, both for use in markets and also in fruit gardens, a number of different kinds of Climax baskets were imported from Glasgow. These are sent out, nested, with the metal handles separate. They were put on the market, at Quetta, and sold at six, eight, and ten pice each, according to the size. These baskets (Fig. 3) are exceedingly neat and clean, and are much more attractive than the ordinary tamarisk baskets available in fruit gardens at Quetta, which cost about the same. They can also be used for taking fruit for railway journeys, and for this purpose might find a ready sale on the Indian railways. They are so cheap that they can be thrown away after the journey. On account of thefts in transport Climax baskets cannot, of course, be used for sending fruit by train, as in the case of the strawberry trade in England.

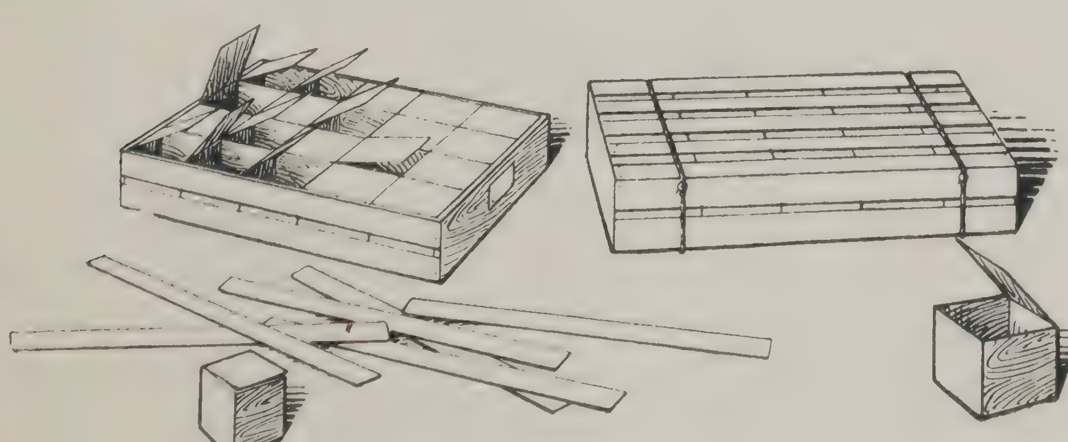

FIG. 3.—CLIMAX FRUIT BASKETS.

4. *Non-returnable crates.*—For the wholesale fruit trade in India there is no doubt that a suitable non-returnable crate is greatly needed at the present time. Some attention has therefore been paid to this matter during the past two years. As a result, a cheap, light, non-returnable crate, holding 24 punnets,

has been designed, tested, and put on the market. By this means, tomatoes, grapes, and peaches were successfully sent from Quetta to Calcutta, in 1912, without loss or damage in transit. The distance is approximately 1,750 miles and the journey takes about four days. The consignments had to withstand not only the dry heat of the desert as far as Delhi, but also the high temperature and high humidity of the monsoon period on the journey through the Gangetic plain.

For long journeys, non-returnable fruit packages must be strong, light, and cheap, and there must be good ventilation; they should be as attractive as possible and should look clean and fresh; the weight when filled should not be too great, and the cases should be easily handled by the railway staff; the package should be capable of being closed, rapidly, in such a manner as to make thefts in transit exceedingly difficult; the fruit must be packed sufficiently tightly to prevent any movement in transit, and the upper layers must not press on the lower; further, the boxes must be able to travel equally well in any direction. These conditions were fulfilled by the use of the non-returnable crates illustrated in Fig. 4.

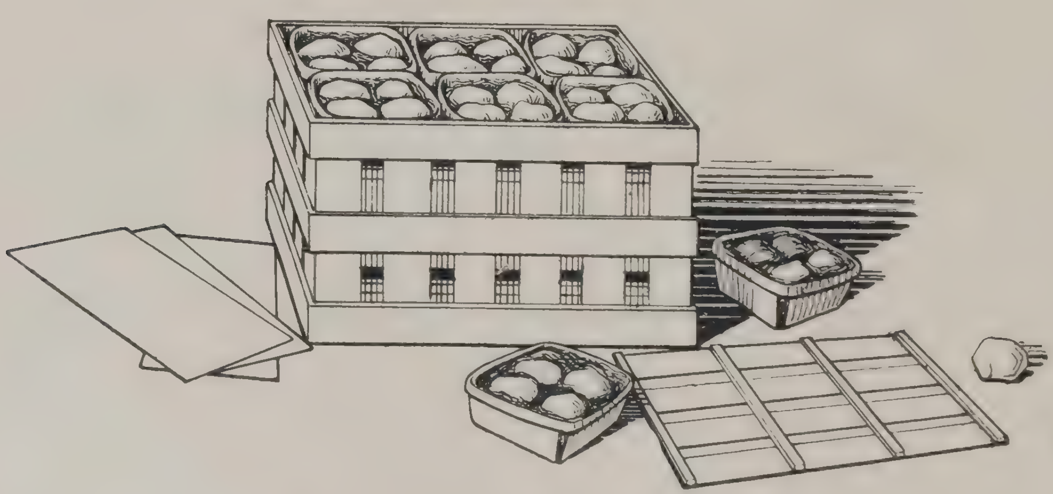

FIG. 4.—A NON-RETURNABLE CRATE.

These crates, which measure $24 \times 16 \times 13\frac{1}{2}$ inches and weigh $5\frac{3}{4}$ seers, contain 24 punnets, each $7\frac{1}{2} \times 7\frac{1}{2} \times 3$ inches, arranged in four layers separated by floors. Six of the punnets exactly fit the crate, and a light floor, made of laths and fixed together

with cross pieces, rests evenly on the edges of the punnets below. In this way the weight of the upper layers is supported without injury to the fruit. The cross pieces tend to keep the punnets in place and prevent lateral movement. The crate is closed by nailing on the thin boards, and a wire is passed lengthwise round the box, through the corners, and finally sealed with a lead seal : theft in transit is thus rendered practically impossible. The weight of the crate, when filled with fruit like tomatoes, is about 29 seers, so that it comes just under the 30-seer rate. These crates complete were placed on the market, at Quetta, in 1912, and sold at the rate of two rupees each.

In packing these crates several matters require attention. The fruit should be carefully picked in the early morning, when cold, into padded trays or baskets, and the grading and packing should be done on padded tables, in the shade, so as to prevent bruising. Delicate fruits, such as peaches, nectarines, grapes, and tomatoes, should always be wrapped in thin paper before packing. This not only prevents damage, but also delays the rise in temperature of the fruit, on the journey through India.

It is found that consignments of cold, wrapped fruit heat up very slowly—compared with non-wrapped parcels packed in the ordinary way. Wrapping checks the ripening processes, on the journey, and lengthens the life of the produce. In this matter Baluchistan possesses a natural advantage over its competitors in the fruit trade, as all the benefits of precooling before transport can be obtained for nothing.

The packing of the punnets should be firm enough to prevent any movement in transit and, for this purpose, some cool, resilient packing material—like *san* fibre—is a great advantage.

The system of separate punnets, packed in one crate, enables mixed consignments of fruits to be made up without difficulty. By this means these non-returnable crates can be used for other purposes as well as for the wholesale trade. Private customers, while unable to use a crate of any particular fruit, might easily take crates containing five or six different

kinds of fruit and several sorts of out of season vegetables in addition—such as peas and beans, which are not seen in India during July, August and September. In 1912, several mixed consignments of peaches, plums, grapes, tomatoes—as well as peas and beans—were sent from Quetta to Calcutta and Simla. Several of the Quetta fruit dealers are considering how they can make use of these mixed consignments in extending their business with India.

One further advantage of this method of packing should be mentioned. This relates to the ease in marketing when fruit is sent in units. These small packages save an enormous amount of time in unpacking and selling when the market is reached. There is no rehandling and sorting of the fruit; each unit is ready for sale; and the punnet serves as a clean and attractive gift package in which the produce can be taken away without trouble or damage.

The way in which fruit is exposed for sale is an important part of the business, and the more attractive the unit the better. There seems no reason why this method of sale should not be taken up widely in the various Indian markets. The units can be arranged easily on the present fruit stalls, and, even if sold by weight, the package and its contents can easily be weighed together. If such a system is adopted, there is no doubt that a great reform in the present methods of marketing will have been made.

Returnable crates.

For short journeys on the North-Western Railway—such as Quetta to Karachi or Quetta to Lahore—returnable crates, on the same principle as the non-returnables, were designed. Each contains 24 punnets, in four layers, but the crates are fitted with hinged lids, and can be closed by means of padlocks. They are iron bound at the corners, and are strongly made so as to withstand frequent journeys by train or on camels, to places like Ziarat. It is possible they may be taken up for the Kandahar fruit which is now packed in wicker baskets and sent on donkeys to the railway at Chaman. For railway transport their use

will probably become general as soon as the rules and rates for returned empties are made uniform on the Indian railways.

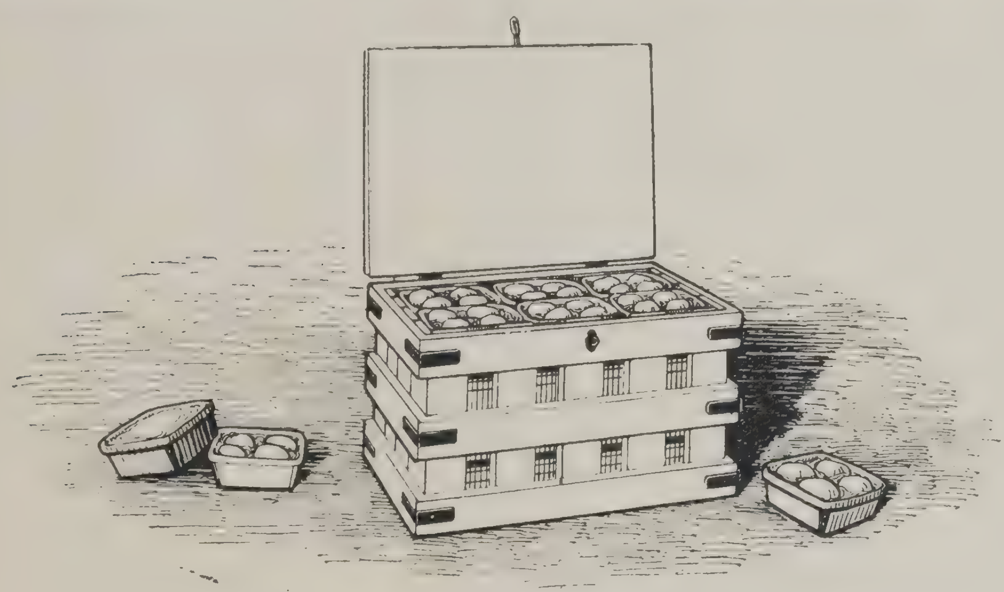

FIG. 5.—A RETURNABLE CRATE.

The cost of the above non-returnable packages must now be considered. The rates charged by the manufacturers, in 1912, were as follows. (In all cases except when otherwise specified, the figures quoted are rupees per gross)—

1. Peach crates, twenty size, Rs. 15-8.
2. Peach crates, fifteen size, Rs. 15-8.
3. Material for 3″ cubes, Re. 1-2.
4. Material for 3½″ cubes, Re. 1-5.
5. Non-returnable crates per dozen, Rs. 5-10.
6. Grape boxes, large size, Rs. 15.
7. Climax baskets with covers, large size, Rs. 14-10.
8. Two-pound punnets for the non-returnable crates, Rs. 4.

The prices naturally vary a little with the value of wood, but the above represent roughly the cost of these packages, at Glasgow, in 1912. Packing, ocean freight and other charges would of course be additional. In the Quetta consignment of 1912 these extra charges—including packing, freight, agents' fees at Karachi (which are very high), customs duty at the port, octroi at Quetta, and railway freight—came to fifty-five per cent. of the original cost. These expenses, however, could probably be

reduced in the case of larger consignments ordered in the regular course of business. One of the chief items was agency fees at the port, which would be saved in the case of consignments ordered by Bombay and Calcutta dealers.

The *san* fibre used in the experiments was obtained in pressed bales from dealers in Oudh, and cost Rs. 4 per maund, while the automatic stapling machines, for putting together the peach cubes, were supplied by the Army and Navy Stores, Bombay, for Rs. 3-12 each. The cost of the staples was one rupee a thousand. For work on the large scale a wire stitching machine would probably be cheaper than these hand stapling presses.

IV.—The Marketing of Fruit in India.

The disposal of the produce.

The present system of disposing of the fruit crop in Baluchistan is not very advanced. The usual method is for the *malik* to sell the year's crop of any garden to a fruit merchant, often a Hindu, for a lump sum—the picking and packing being done by the dealer. Some of the produce is sold locally, and the prices charged in the Quetta fruit market are, on the whole, exceedingly high. The rest of the fruit is sent to India, a large portion being consigned to agents in the Crawford market in Bombay. These agents are said to be unreliable and to give good prices at the beginning of each season, but practically nothing for later consignments. It is commonly supposed that they form rings for the purpose of reducing the price to the senders of consignments, and that they generally regulate the market for their own benefit. If these statements are true, it is obvious that this state of things stands in the way of progress, and that some reform is necessary in order to enable the grower to obtain a fair share of the profits of his labour.

The growers and local dealers can be assisted in their business in three ways. In the first place, they should take steps to obtain official statements of the retail prices of their produce,

charged to customers, in the large markets in India. Such statements are issued to the press in cities like Calcutta and Bombay, where the markets are under efficient Market Superintendents. It would not be a difficult matter to have these statements disseminated in the chief centres of fruit production. A knowledge of these prices would naturally help those interested in the fruit trade to cope with their agents at Bombay and other centres.

The second line of advance in this matter would be an efficient method of auctioning fruit at markets like Calcutta and Bombay. These auctions would have to be conducted under the supervision of the Market Superintendents, and the growers would have to be prepared to take their produce off the market in case the dealers attempted to form a ring for the purpose of controlling the market. This method of disposal was suggested by the Market Superintendent at Calcutta, and there appear to be no real obstacles in the way.

The third and perhaps most important way of helping the trade would be to establish agencies in the chief markets, under European supervision, which would be outside any rings made by the Indian dealers. An experiment is in progress, in this direction, in Calcutta, where the Great Eastern Hotel Company proposes to rent a fruit stall in the New Market, during 1914, for the sale of Quetta fruit and vegetables sent from the Experiment Station. The produce will be exposed for sale in the unit gift packages referred to on pages 256-7, and every effort will be made to place superior fruit and vegetables before the consumers. In this experiment the co-operation of the Deputy Chairman of the Calcutta Corporation, and of the Market Superintendent, has been obtained, as well as the active interest of the Great Eastern Hotel Company.

Refrigeration and Cold Storage.

The recent advances in the methods of artificially cooling fruit before and during transport on the railways of the United States, and the spread of cold storage facilities at the principal markets in that country, have drawn attention to the possibility

of utilising these devices in India. Perishable fruits like peaches are now precooled before loading, and then sent, in refrigerator cars, from the orchards of California to the markets of the Eastern States. The cold storage warehouses, in which meat and fish are stored for long periods, are also used for apples and similar fruit. At first sight there seems no reason why these methods should not be adopted immediately in India, and the problems of the successful transport and storage of perishable products like fruit instantly solved by simply copying what has already been done in California.

The conditions of the fruit industry in the United States are, however, quite different from those in India. In California, Georgia, and other important centres, fruit is grown, to perfection, in vast quantities, and it is possible to fill whole vans—and whole trains—in or near the orchards, and to erect all the cooling plant necessary. In the Eastern States, large cities exist where well-to-do purchasers abound, who do not mind paying high prices for fruit offered in an attractive manner. In India, the conditions are altogether different; the quality of the fruit at present produced is relatively poor, and the amount is small: the methods of packing are primitive, and merchants do not exist who are capable of handling the business in a large way: further, there are no markets for fruit in India comparable with those of the United States; the number of Europeans in the plains during the monsoon period falls to a minimum, and they are quite unable to pay high prices for fruit, although they are willing to buy it if it is good and fairly cheap.

In 1911, and again in 1912, some first hand experience was obtained relating to the prices likely to be obtained in India for good fruit, properly packed. A large number of packages of Quetta fruit were sent for sale to clubs, hotels, shops, and to various private individuals, as well as to Indian fruit dealers in the large cities. The fruit was sold for the highest prices obtainable, and in this way a fairly accurate idea of the possibilities of the Indian market was obtained. In addition, visits were paid to the public markets of cities like Bombay, Calcutta

and Lahore, where the Market Superintendents and various Indian dealers were interviewed. The result of these experiments and enquiries was to show that there is a considerable demand for good, well packed fruit, at moderate prices; but there is hardly any demand for fruit, however excellent, at what may be described as really high prices. In the larger markets, the methods of handling fruit are still primitive, and a great deal remains to be done before even Calcutta will be in a position to handle van loads of fruit sent by refrigerator cars. Further, between the fruit growing areas of the North-West Frontier, and Calcutta and Bombay, there are no large cities which could dispose of van loads of cooled fruit at prices likely to be remunerative. A consideration of all the circumstances of the present fruit industry in India, therefore, discloses the fact that there is no immediate prospect of success for refrigerator cars on the Indian railways. It is possible, however, that, in the future, there may be a demand for this class of transport. This will depend mainly on the needs of the Indian section of the population. If a great demand for the fruits of the North-West arises from the people themselves, and if they prove willing to give prices that would pay for cool transport, then it would be easily possible to meet these demands and to follow the lead of California. At present this demand does not exist, and the Indian population seems satisfied with semi-tropical fruit like bananas, mangoes, and guavas, which can be transported by the present methods, provided this produce is picked sufficiently unripe.

Improved Railway Facilities.

Speaking generally, the present railway facilities in India are in advance of the fruit merchants, whose methods of packing are primitive in the extreme. On several railways excellent fruit vans with good ventilation have been provided, for use in connection with the mail trains. At the same time several railway reforms relating to rates and regulations are urgently called for. One of the consequences of the large number of

Railway Companies in India is the want of uniformity in the rules relating to the transport of fruit and the return of the empty packages to the sender.

One direction in which the Railway Companies can help the fruit trade is in weighing and booking a number of packages together, when sent to one consignee. On many railways, each package is now weighed separately and charged for at the next highest point on the scale. Thus ten crates, each weighing 28 seers, would be charged for as ten 30-seer parcels and not as seven maunds. This concession—of charging for fruit on the collective weight of the consignment—could easily be granted to the users of packages of standard size and pattern like those referred to in this paper; the cost to the Company would be more than repaid by the increased carrying power of their vans and the greater ease in dealing with the traffic; it would act as an inducement to merchants to use standard boxes, and would lead the way to whole van consignments to one market. This concession is already in force, to a limited extent, on both the East Indian Railway and on the Bengal & North-Western Railway. It only requires to be made uniform and universal in India, for the improved fruit packages.

Another direction of progress relates to the return of empty fruit boxes, from the markets to the senders. In this matter the rules on the various railways are exceedingly uneven, and several hampering restrictions exist. Thus, on the Bombay, Baroda and Central India Railway, empty fruit packages, if carried at quarter parcel rates, must be returned to the station of arrival within seven days; otherwise full rates are charged. In other cases the time limit is ten days, while on the North-Western Railway and on the Oudh-Rohilkhand Railway fruit boxes are returned free, on certain sections of the line. A great deal could be done to help the trade if the railways could arrange for the free return of fruit packages of standard size, and also agree to abolish all hampering restrictions as to minimum rates and dates of return. This would be a material inducement to dealers to adopt better methods of packing and also to use the unit gift packages like those referred to above (pp. 256 and 257).

The question of the numerous thefts in transit, on the railways, remains to be mentioned. These cases are exceedingly numerous and they amount to nothing short of a scandal. At the present time, each package has to be securely fastened and sealed, somewhat after the manner adopted in sending insured articles by post. It is obvious that this involves a vast waste of labour and also increases the cost of fruit to the consumer. Fruit packages sent long distances must be ventilated, and to secure such parcels from theft is a difficult matter. The adoption of adequate remedies against theft, capable of being carried out in practice, is obviously a matter that can only be dealt with by those conversant with the details of Railway management.

V.—Conclusions.

It now remains to sum up the various subjects dealt with in this paper.

1. Experience at Pusa and Quetta has shown that the present methods of growing and transporting fruits, in India, are exceedingly primitive, and that far better results in both these directions are easily possible.

2. In the plains, delicate fruit like peaches can be transported without damage, when practically ripe, by means of bamboo baskets containing small cells for each peach.

3. Non-returnable packages, made of wood and chip imported from Glasgow, have been put on the market, at Quetta, at prices within the means of Indian fruit dealers. By means of these packages delicate fruit like peaches, grapes, and tomatoes can be sent to Calcutta, a distance of 1,750 miles, without loss or damage.

4. At present the ideal system of sending fruit on a large scale, to distant markets, is to adopt a suitable unit gift package, such as a punnet, and to pack these in non-returnable crates. These units should be sold as such, direct to the customer.

5. All delicate fruit should be wrapped in paper. The most suitable packing material so far found is *san* fibre, obtained in pressed bales from Oudh.

6. For short distances especially on the North-Western Railway where empties are returned free, there is an opening for returnable fruit packages such as those described in this paper.

7. In marketing fruit, it would be an advantage if an arrangement could be made to obtain, daily, the retail prices charged in the Bombay and other large markets. Efficient fruit auctions, at the larger centres, would be an advantage to the grower.

8. At present, in India, the provision of refrigerator cars for fruit on the railways, and cold storage facilities at the markets, is not likely to pay.

9. The rules for the transport of fruit and empty packages on the Indian railways are not uniform. Arrangements should be made to grant two concessions to the users of fruit packages of standard size ; in the first place the consignments should be charged for on the collective weight and not on the weight of each separate package ; in the second place returned empties should be carried free.

10. Thefts in transit should be reduced to a minimum.

THE ORGANIZATION OF SEED FARMS IN THE CENTRAL PROVINCES.

BY

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THE Central Provinces Agricultural Department has for several years paid particular attention to improving the types of seed in common use among the cultivators of these Provinces. This, in fact, may be considered almost the chief business in hand at present.

The general adoption of better methods of cultivation, important as it is, is an objective which will only be attained after years of patient efforts. To popularize improved implements and labour-saving machinery will also be a matter of time, owing to the absence of capital and initiative among the agricultural classes themselves. On the other hand, the staple seed supply of the Province affords scope for an immediate improvement, simple to demonstrate and easy to perceive, the practical adoption of which presents no serious difficulty to the average farmer. The present supply is of inferior quality and contains an admixture of more than one variety. The product is poor, variable, and of no recognized commercial status. The testing and introduction of improved varieties, and the inculcation of the doctrine that the crops raised from pure seed are the more profitable to grow, constitute therefore at the present time one of the most important aspects of the local Department's work. This article proposes briefly to describe the various types of seed farms at present in existence in the Central Provinces, showing how each type has developed and what progress it has so far made.

2. In the first place the isolation of pure high class varieties—a matter of primary importance considering the inferior mixtures now being grown—is undertaken on the Government farms. This branch of work presents comparatively little difficulty to the trained investigator, though several years of laborious selection, testing, and propagation are generally necessary before sufficient seed of the improved variety is available for trial by the public at large.

The next step is to advertise the seed by means of demonstration plots, exhibitions, and agricultural meetings. It is then handed over to selected members of the District Agricultural Associations, and under the supervision of the Department is tried on a field scale under varying local conditions. The outturn is compared with that of the common local variety, and, when results are favourable, a local demand for pure seed soon springs up.

This is seed farm organization in its simplest form, *i.e.*, a central area directly controlled by Government, feeding small private plots owned by well disposed farmers in the neighbourhood. The co-operation of the farmers is necessary because the Government Agricultural Stations are far too limited in area to be able to meet a growing demand for the new variety of seed. In every district of the Central Provinces an Agricultural Association of the leading land owners has been formed, and in the absence of a better organization these are, as above stated, utilised as the agency for the dissemination of the pure seed from the Government farms. The seed is sold exclusively to members of the Associations, each of whom agrees to grow it on a properly managed seed farm.

3. As exemplifying this form of organization it may be stated that this year 42 seed farms for selected kinds of wheat were under the supervision of the Department in the Northern wheat tract. These seed farms are arranged in groups within easy distance of a good grain market so that the surplus produce, as soon as the demand for seed in the neighbourhood has been satisfied, may realise a full price, and thus further emphasize the

advantage of growing pure varieties. Definite rules of management are prescribed. The growth of two varieties is prohibited; and the necessity for a separate threshing floor for the new crop, separate storage of the produce, and regular inspection by the itinerant Agricultural assistant in charge of the circle, is emphasized. The area to be sown in the case of wheat must not be less than 25 acres in the first instance. Otherwise it is found by experience that the grower will not make a separate threshing floor. Reports on these seed farms are submitted at each meeting of the Agricultural Association.

4. The organization through District Agricultural Associations is defective, in so far as it is difficult to get the essential rules properly carried out, in the branch seed farms, by large land owners (of which the District Agricultural Association is primarily composed) actuated more by a desire to please than by any real idea of practical business. But after two or three years it is generally found that a more highly articulated system comes almost spontaneously into existence, as the cultivators begin to realise the benefits of combination. Diversity of agricultural interests even within a single district develops smaller units of control. Thus a Sub-Association was started three years ago near Seoni-Malwa in the Hoshangabad district in a small tract suited to a certain variety of *maghai* til. The new variety was not known on the local markets and when sold in small quantities realised no better prices than the local til. But by marketing the total surplus produce on a single day an extra Rs. 3 profit per acre sown was obtained, and that without necessitating the slightest change in the current method of cultivation. In the third year (1912) over two thousand acres were sown and the market is now well established. Now even the Sub-Association is being split up. The new til deteriorates rapidly by cross-fertilization with the indigenous variety, and realising this, the cultivators of small groups of 15 to 20 villages each, are arranging to exclude the local til altogether, and have engaged the services of a trained farm hand whose duty it will be to see that the quality of the seed sown

is up to the mark. Each group has a central seed farm or seed farms supplied with fresh selected seed from time to time from the Government Farm. The above is an excellent example of how the loose organization of seed farms under the District Agricultural Associations splits up naturally into smaller areas of control shaped by community of interest.

5. In Berar a somewhat parallel but even more articulated development in the control of seed farms has occurred. After much experiment on the Akola Farm, a variety of cotton known as 'Rosea' had been found to give the best profits, per acre, to the local cultivator. It is short stapled but hardy and prolific, and has a high ginning percentage. The demand for seed is very great, 'Rosea' seed often fetching more than twice the price of the ordinary local variety. Last year 90 privately owned cotton seed farms, of the nature of the wheat seed farms described above, were growing 'Rosea' cotton. But for the whole of Berar 500 such seed farms would scarcely suffice; and the question of a local organization to control the ever-widening circle of seed farms arose in a very prominent manner. Here, too, as in the Hoshangabad district, Co-operative Credit is in its infancy and could give no help. Direct supervision by the Agricultural Department was also manifestly unsuitable, and the District Agricultural Associations were clearly incompetent to grapple with the situation. After much consideration it was decided to organize by official agency local areas of control smaller and more definite in shape, but following the line of development indicated by the groups of the Seoni-Malwa Sub-Association. As an experimental measure three so-called Agricultural Unions have accordingly been started. Each Union controls some 500 acres, growing improved cotton, in a small circle of adjoining villages. Each employs a Kamdar trained, in cotton cultivation and selection, by the Agricultural Department, and paid by the levy from the cultivators of $1\frac{1}{2}$ to 2 annas per acre sown. Each Union will eventually, it is hoped, have a small, power ginning plant of its own. In this way a very large area should be sown with

pure seed in the course of the next few years. Other improved strains, obtained from the Government Farm as occasion arises, will also be disseminated through the agency of these Unions.

6. But even the Berar system is admittedly incomplete, and will not be expected to reach its fullest development until, as in the Jubbalpur district, these Agricultural Unions controlling the seed farms are brought into close connection with a number of Co-operative Credit Societies. This consummation has been achieved in the Sehora Tahsil of the Jubbalpur district for the simple reason that nearly two-thirds of the villages of that Tahsil have now each its own Co-operative Society. Certain enlightened members of the Jubbalpur Agricultural Association have, for the last five years, been trying new varieties of wheat, gram, etc., with a view to improving the present poor quality of the crops. The variety known as Sukerhai Pissi was found to yield far better than the local wheats and to realise a higher price if marketed in bulk. Two other varieties known as *Bansi* and *Hansi* were also found to suit certain classes of soil and position. A new variety of gram and several new rices were proved to be profitable. Four large wheat seed farms of the usual type were started, but although they comprised an area of over 300 acres the demand for seed in the first year far exceeded the supply ; and it was evident that if the demand was to be met, a number of seed farms would be needed which it would be impossible for the Department to supervise. After much discussion and many initial mistakes the following system has been finally evolved :—

Agricultural Unions, composed of Co-operative Societies, and not of individual members, have been formed. Each Co-operative Society appoints one of its members to act as Kamdar or Manager ; and he is responsible that the individual members carry out the rules intended to ensure that the new varieties are kept pure. Once or twice a year the Union Committee meets in the central village. It is composed of the Kamdars of the various Societies which are incorporated in the Union. The President is a leading Malguzar who has a large seed farm on

which fresh seed from the Government Farm is grown each year The President, besides being a member of the District Agricultural Association, is also a Director of the Co-operative Central Bank at Sehora. At these meetings each Kamdar reports what his Society requires for the following season and how much surplus stock is available for sale. In order to purchase the seed they require, individual members borrow money on the usual terms, from the Central Bank. The Kamdar receives a small annual remuneration from the other members of the Society in return for the services he renders.

Incorporated with the Agricultural Unions is a Central Seed Store, situated in the buildings of the Crosthwaite Central Bank, Sehora. This seed store registers orders for seed, and arranges the supply from the incorporated seed farms. It also arranges for the disposal of surplus produce in bulk, so that the highest possible price is realised and full value for the improvement in quality obtained. The seed is graded by a specially trained man, and no seed not up to standard is thus sold for seed from the seed farms. The managers of the store will eventually be responsible for the supervision of the Kamdars of each Agricultural Union, but at present this duty is being performed by an Agricultural Assistant until the Seed Store is in a position to obtain a better trained staff.

7. Three such Agricultural Unions have, at present, been organized :

The *Bargwan Union* consists of 9 Co-operative Societies in the villages immediately surrounding Bargwan, the farthest not more than 5 miles away. The President is Rai Sahib Gurudin Misra, Director of the Central Bank, who resides at Bargwan and has a large seed farm of 400 acres. Many cultivators already grow improved varieties in these villages and this year the following quantities of pure seed have been ordered by this Union alone :—

Sukerhai Pissi	 41,880	lbs.
Bansi wheat...	 15,200	,,
Malida gram	 7,000	,,

The area under pure varieties controlled by the Union this season will be approximately 1,600 acres.

Two other Unions are in process of formation, controlling an area of about one thousand acres.

8. The Jubbalpur organization is, as will readily be seen, by far the most advanced, and remains for these Provinces the standard to which it is hoped gradually to raise the supervisory system of the other districts. But no mere imitation will give the best results, and every opportunity is being allowed to the Association of Hoshangabad and to the Unions of Berar to develop along the natural lines most likely to suit them. The one accepted principle, however, is this, that, wherever Co-operative Societies exist, the Agricultural organization must be worked through them, to the mutual advantage both of the Societies and of the system of control, whatever it may be, under which the seed farms may be placed.

It is hoped within a few years that Co-operative Credit Societies will be organized in all the districts where Agricultural development shows the greatest promise. The linking of these Societies into small self-supporting and self-regulating Unions, themselves co-operative in form and practice, will then constitute the agency through which in common with other agricultural improvements we shall be able to foster the dissemination of the higher types of pure seed.

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THE CULTIVATION AND TRANSPORT OF TOMATOES IN INDIA.

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I.—Introduction.

In connection with the work relating to the development of the fruit industry of Baluchistan the question of the profitable production of vegetables for the Indian market was considered. Some of the English vegetables grow to perfection at Quetta and are ready for the market in July, August and September. Such produce is almost entirely absent from the markets of the Indo-Gangetic plain at this period, so that Quetta grown vegetables would be likely to sell at remunerative prices in the plains of India if suitable methods of transport could be devised. Accordingly, a beginning was made in this work in 1911 when a few experimental consignments of tomatoes were sent to Calcutta, a distance of 1,750 miles. These preliminary trials showed that the quality of the produce was all that could be desired and that a good market for out of season vegetables existed in Calcutta. In the following year, 1912, it was decided to extend the experiment and to try an improved system of packing. At the same time, the methods of cultivation of this crop, both in the plains and in Baluchistan, were studied. The fact that the tomato

grows very easily, and produces fruit without trouble, probably accounts for the want of care devoted to this plant. Only in one case, namely, in the garden of Colonel Duke, I.M.S., Residency Surgeon and Chief Administrative Medical Officer in Baluchistan, were properly cultivated tomatoes observed. Here the plants were trained on wires, two stems to each plant, and all the side suckers were pinched off. The result was large crops of well-grown, evenly ripened fruit which could be picked without damaging the plants. It was decided to adopt this system on a large scale, combined with furrow irrigation; and, accordingly, experiments were made at Pusa, in Bihar, in the *rabi* season of 1911-12 and again at Quetta in 1912. In both cases the results were successful. A portion of the Quetta crop was sent to Calcutta where it was sold at good prices, the remainder being disposed of locally, to Army contractors, at the rate of three rupees a maund. The area under experiment at Quetta was four-tenths of an acre, for which a sum of Rs. 842 was obtained, although at least half of the crop was destroyed by abnormally early frosts in August and September, and could not be sold. About 10 tons of saleable fruit was, however, collected from this area, the yield being at the rate of 25 tons to the acre. Similar crops were obtained at Pusa in 1911-12 and again in 1912-13. These experiments have been so striking that it has been decided to publish the results, in the hope that more attention will be paid in the future, in India, to scientific methods of production in vegetable growing.

II.—The Cultivation of Tomatoes.

Seedlings.—Insufficient attention is paid, in India, to the raising of the tomato seedlings and young plants. The best results are obtained when the seedlings are transplanted in the nursery, once, and this should be done when the first pair of rough leaves are fairly well developed. They should be set out in a well prepared nursery, about three inches apart each way, and should be planted deeply—the stem up to the seed leaves being completely buried. Care must, of course, be taken to accomplish this

transplanting without serious damage to the roots. The seedlings should first be well watered about two hours beforehand and then taken up by means of a small trowel with as much moist earth adhering to the roots as possible.

After transplanting, the nursery should be well watered, and the surface, when dry enough after each watering, should be broken up and kept in a fine condition. This cultivation, which is usually neglected in India, is most important, as also the proper spacing of the seedlings. In this way vigorous, stocky plants are produced and there is no check in growth, an important point in the case of the tomato. The young plants must be well watered, but not overwatered, and when the stems are as thick as the little finger and the plants are five to six inches high, they are ready for the final planting out. The Indian gardeners, if left to themselves, are not likely to succeed in this portion of the work of tomato growing; through overwatering and want of cultivation they raise weedy, drawn, weak plants with hardly any roots, which die off wholesale after the final planting out.

Irrigation.—The irrigation of the tomato crop is an important matter in India, not only in the arid climate of Baluchistan but also in the plains. In the application of irrigation water to tomatoes two conditions must be fulfilled. The plants must get sufficient water, both for vegetative growth and also to swell the fruit, and it must be remembered that the tomato does not like dry soil. At the same time the tilth must on no account be destroyed, otherwise the plants will not thrive and will not yield the maximum crop. Surface flooding, the usual method of irrigation at Quetta, is therefore out of the question, as by this means the tilth is destroyed and, in addition, an enormous amount of water is lost by evaporation, particularly during the period of the dry westerly winds. The easiest method of applying water without destroying the tilth is by means of furrow irrigation. This system has the additional advantage of saving a large amount of water.

The method of irrigation by means of furrows is particularly applicable to fine alluvial soils, in which the lateral percolation

PLATE XXX.

FURROW IRRIGATION.

from a trench filled with water is considerable. This system of irrigation presents no difficulties. After the final preparation of the land, furrows, about 18 inches wide at the top and from 4 to 5 inches deep, are laid off at the proper distance. The floor of the trench should be about 15 inches wide, and the sides should slope so as to prevent the furrows filling with earth from the edges. The land should be laid out so that there is a furrow between alternate rows of tomatoes.—Plate XXX shows the arrangement in the case of tobacco. The rows of tomatoes should be at least three feet apart, and the plants should be spaced from two to three feet in the row. In laying out the land, it is an advantage to mark the position of the ends of the rows of tomatoes first of all, by means of pegs, and then to make the furrows. After the land between the trenches is levelled, the lines of tomatoes can be laid off and the positions of the plants indicated by short pieces of twig or straw.

Water is given by filling the furrows, whenever this is necessary. It should be remembered that while the tomato does not thrive in dry soil nevertheless overwatering during the ripening stage leads to much splitting of the fruit. No rule can be given as to the amount of water required to suit all circumstances. In this matter the successful grower soon learns to read his practice in the plant itself.

Planting out.—Two or three days before the final transplanting, the furrows are filled two or three times from a distributing channel which runs at right angles to the trenches. The water percolates laterally, and soon the soil is well moistened between the furrows. As soon as the earth is dry enough for the purpose, the tomato plants are set out in the soil which has been moistened by the lateral seepage from the trenches. The plants should be deeply planted, right up to the leaves, and the soil should be properly consolidated round the roots. About half the leaf surface of the older leaves should be pinched off, and the young plants covered by means of leafy twigs during the day for the first two days. In this

way the losses on transplanting are exceedingly small, a good even stand of plants is obtained, and there is very little check in growth

Cultivation.—After the plants are established the cultivation of the surface is an important matter in this crop. The aim should be to maintain a dry surface mulch on the beds and around the plants, and to keep down all weeds. The labour involved in this is much reduced by the use of the Planet Jr. double wheel hand hoe, which can also be used to break up the crust which forms on the floor of the furrows as these dry. In an arid climate, like that of Baluchistan, the loss of water by evaporation from the furrows is very great and, unless the crust is broken up, cracking takes place and the moistened soil sets into a hard intractable cake. In addition to this surface cultivation, the earth of the beds between the young plants should be deeply cultivated after planting out, at least once, with

FIG. 1.—A PICKAXE (*kodár*) USED FOR DEEP CULTIVATION IN THE PLAINS OF INDIA.

the *kodár*, a kind of pickaxe shown in Fig. 1. This aerates the subsoil after the trampling of the workmen, and leaves it in the proper condition for rapid root development.

Pruning and training.—The method of pruning adopted, and also the system of training, are matters of great importance in the cultivation of the tomato. Both these subjects receive little or no attention in India.

If left to itself, the tomato produces a large straggling growth, which sprawls over the ground, rendering the collection of the fruit a matter of great difficulty. Under these circumstances, most of the tomatoes lie on the damp earth, and the amount of decay is considerable. The fruit produced is small in amount and often deficient in flavour. The absence of sufficient sunlight also prevents the proper development of colour. These results follow from the unchecked vegetative growth of the plant. Instead of the energies of the tomato being used for fruit production only, a large number of unnecessary branches are developed, which interfere with the well-being of the crop. Some system of pruning is, therefore, essential. The method adopted at Quetta and Pusa is to restrict the vegetative growth to two branches only and to pinch off all other growth. As is well known, the main stem of the tomato plant, when a few inches in length, ends in a bunch of flowers. On either side of this a lateral branch is formed. These laterals themselves will give off other branches and further branching will take place on the lower portions of the single main stem if the plant is left alone. The object of pruning in this crop is to remove all side branches, which form on the two laterals and on the single main stem, as soon as possible. This is done by pinching off these shoots as they appear. The whole growth is, therefore, deflected into the two main arms, which rapidly grow in length and give rise to successive clusters of flowers.

In addition to pruning, some method of training is necessary for the tomato. The stem is too weak to stand erect and at the same time bear a heavy crop of fruit. The absence of bamboos at Quetta and the scarcity of wood, account for the fact that the local gardeners make no serious effort to train the tomato. In India, more is done in this respect, and tomatoes are often seen

either supported by vertical or inclined bamboo frame work. A more effective arrangement is to train the plants on wires, supported either by short poles or by the ordinary iron standards used in wire fencing. The wire and iron standards can be used over and over again, while, in a dry climate like Quetta, short willow poles will last several years if properly stored. The posts for supporting the wires should be from four to four and a half feet high when placed in position, and either three or four wires should be used. The lowest wire should be about nine inches above the ground, and the highest should run level with the tops of the poles. Between these, the other wires should be arranged, at regular distances. The plants can be tied to the wires by means of banana fibre or strips of mulberry bark. Trained in this way the tomato forms almost solid walls of green foliage loaded with fruit, after the manner shown in Plate XXXI. There is plenty of room for development, the fruit receives the necessary sunlight, and even ripening takes place. Picking is greatly facilitated, and no damage is done to the plants in the process. Moreover cultivation can go on uniformly till the whole crop has been gathered.

III.—The Packing and Transport of Tomatoes.

The results obtained at Quetta in 1912 proved that tomatoes could be sent to Calcutta, without loss or damage in transit. The distance is approximately 1,750 miles, and the journey takes about four days. The consignments had to withstand not only the dry heat of the desert as far as Delhi, but also the high temperature and high humidity of the monsoon period on the journey through the Gangetic plain.

These results were not achieved without some attention to detail. In bringing this portion of the work to a successful issue it was found that the most important matters were the following :—

1. *Picking.*—The tomatoes must be picked at the proper stage neither too green nor too ripe. If too ripe and soft when packed the fruit does not last long enough in good condition, after arrival, for sale purposes. If picked too green, the full

PLATE XXXI.

TOMATOES ON WIRES.

TWO-BRANCH SYSTEM.

flavour does not develop. Good results were obtained when the tomatoes were gathered when they were beginning to turn red all over and before all the green colour had disappeared. They are best picked by twisting off the fruit from the stalks, and they should be packed without the stalk, as this often projects beyond the base of the fruit and causes damage to other tomatoes.

2. *Wrapping.*—The fruits should be separately wrapped in thin paper, and only perfect specimens should be selected. There is obviously nothing to be gained in the attempt to send second class produce by passenger train to a distant market, like Calcutta, accustomed to handle the best supplies obtainable. Picking should be done early in the morning, when the fruit is cold, and the packing should be done in the shade. By wrapping tomatoes in paper when cold a great transport advantage is obtained. The ripening processes are delayed, and cold wrapped fruit heats up very slowly on the journey. In this respect Baluchistan has an enormous natural advantage over its competitors in the fruit trade. With a little care quite cold fruit can be packed at Quetta and all the advantages of pre-cooling before transport can be obtained without any trouble or expense. This enables fruit to be picked in a much riper condition than would otherwise be possible, thus ensuring the maximum flavour on arrival consistent with safe transport.

3. *Packing.*—The package used for tomatoes is a matter of considerable importance if the journey is a long one. This point has been dealt with elsewhere (p. 256), in connection with the problem of fruit transport in general, and it is unnecessary to do more than refer to it here. They are packed in punnets (Fig. 4, p. 256). Two methods are possible; medium sized fruit after wrapping can be packed edgewise. Large fruits are best packed flat, four in a punnet. In both cases the floor and sides are lined with *san* fibre and the fruit must be tight in each punnet. This is best accomplished by filling up the small spaces by means of the fruit of the smaller varieties such as cherry and pear tomatoes. Care must be taken that the tomatoes do not project beyond the edges of the punnets, otherwise they will be crushed by the floor above. To

fill the punnets completely, a little *sann* can be placed above the tomatoes in each.

These crates can of course be used for other produce besides tomatoes—such as grapes, peaches and plums. In 1912, a number of these packages, containing a variety of fruits and vegetables, were sent to Simla and Calcutta during August and September. It is hoped that by this means the Quetta fruit dealers will supply customers in the plains with mixed consignments of the produce of the valley. The separate punnets enable a variety of fruits to be sent in one package.

4. *Marketing.*—The method of offering fruit for sale is an important matter, and one in which the Indian fruit dealers have much to learn. There should be no sorting or handling of the produce after the market is reached. The ideal method is to offer each unit of fruit for sale in a suitable gift package of such a character as to encourage the purchaser. These units should be packed in outer crates, in the manner already described. For tomatoes, the two pound chip punnet measuring $7\frac{1}{2} \times 7\frac{1}{2} \times 3$ inches is a suitable gift package for every seer of fruit. Put up in this way retail marketing is a simple matter; the units are ready for immediate sale, and there is little trouble to the seller. A large consignment of Quetta tomatoes, packed on these lines, was sold in the shop attached to the Great Eastern Hotel, Calcutta, in 1912,—each unit of one seer fetching twelve annas. The cost of packing and railway freight was about four annas a seer.

There is no doubt that, if proper attention is paid to the cultivation of the tomato at Quetta and to the proper packing of the produce, a large market can be found in India. It has been shown that there is no difficulty in sending the produce as far as Calcutta. In addition to this large market, there are many intermediate towns which could absorb a portion of the crop. Further, the demands of the various hill stations and military cantonments within reach could also be met. The crop is ripe during August and September, when the only vegetables available in India are various insipid gourds. Tomatoes offered for sale at this time would find a ready market.

THE CULTIVATION OF RUBBER BY MEANS OF PLOUGHS.

BY

C. S. THANE,

Manager, Rangoon Para Rubber Estates, Twante.

On several Estates in the mid East ploughs and harrows are now being used as a means of cultivating rubber.

The chief objects of this ploughing may be said to be :—

(*a*) To destroy grass and bury herbage and refuse.
(*b*) To pulverise the soil.
(*c*) To promote fertility.
(*d*) To increase the water holding capacity of the soil.
(*e*) To establish a mulch.
(*f*) To reduce expense.

By using such ploughs as will accomplish the results desired in items (*a*) and (*b*), the other results are bound to follow. Should the area to be ploughed be heavy in grass, refuse, or fallen leaves, the land should be ploughed deeper than if it is clean ; as refuse, leaves, etc., decay more rapidly when ploughed under deeply than if they are turned under with a shallow furrow, because the surface soil is drier.

Nevertheless the depth to plough should chiefly be governed by the nature of the soil and the root system of the trees. Generally speaking, the heavy soils require deeper ploughing than light soils as they need the effect of the loosening, draining and aërating more than light sandy soils, but owing to the root system of rubber each planter can best judge for himself. Three or four inches should be the minimum depth of ploughing.

To destroy weeds and keep the weeding in hand in Burma, fortnightly rounds may suffice until January, after which very

few weeds grow, and then monthly rounds during the dry season : but here again the soil must be taken into consideration, as it is essential to keep a soft mulch of earth on the surface to a depth of 3 or 4 inches.

For pulverising the soil and burying grass, leaves, etc., a disc or rolling furrow plough is generally the best, as it buries and crumbles the soil in one operation. Disc ploughs or harrows are probably the most useful of the many kinds of ploughs in use, being especially good for working heavy soils ; they, however, have one or two disadvantages, they are apt to leave the soil in rather high ridges, which evaporate much moisture ; but this is easily overcome by dragging a small log behind. Also, unless adjusted properly, they leave a ridge of unstirred soil, to avoid this the discs should be set so that they will enter the soil at a wide angle. These disc harrows generally throw the soil from the centre outwards, so that it is necessary to overlap in order to keep the ground level, or else to plough at right angles to the previous time. For bullock draft 8 disc ploughs are the largest that can be used satisfactorily, and here at Twante, for each plough, I have two pairs of bullocks, one day on and one off (water buffaloes should prove just as good draft as bullocks), but I think that by feeding them with a little chaff (paddy straw) and oil cake, it will be possible to use each pair daily ; at present the only feed the cattle have is grass on our reserve area.

Costs.—The daily tasks are three ploughs to ten acres ; one man at 8 as. a day works and drives a plough. The soil is ploughed to within two feet of the older rubber trees and about $1\frac{1}{2}'$ of the young rubber. Between January and June the cost of cultivating ten acres should not exceed 6 annas per acre monthly, made up as follows :—

3 ploughmen @ 8 annas each a day, = Re. 1-8, two coolies @ 8 annas each a day, Re. 1 (for loosening the soil around the trees where the ploughs don't touch). Food for 12 bullocks @ 1 anna each, 12 annas. Oil for ploughs, 1 anna. Sundries, 5 annas. A total of Rs. 3-10 for 10 acres or 5·8 annas per acre.

From June to December, during the wet season, it may be better to work the fortnightly rounds with coolie labour and hoes than by ploughs. At present I have not sufficient data to go upon. If we take A II Division of this Estate of 390 acres, 4 ploughs doing 13 acres a day will cultivate this area once in a month and the following figures will show the total cost per acre per mensem :—

	Rs.
4 ploughmen @ Rs. 15 each p.m.	60
3 coolies „ 15 „	45
Feed for 16 bullocks @ 1 anna each per day for one month ...	30
Oil one month's supply for ploughs, say	1
Sundries, hide for tying yokes, new yokes, bolts, etc. ...	14
	Rs. 150

that is, Rs. 150 for 390 acres or 6·2 annas per acre. For the six months of the dry season, December to May inclusive, it would cost Rs. 900. 4 disc ploughs cost Rs. 195 each, c.i.f. Estate, say Rs. 200 each, = Rs. 800. Taking the life of a plough at 1 year, or two dry seasons, depreciation would be 50 per cent. or Rs. 400—making a total of Rs. 1,300. For these four ploughs are needed 8 pairs of bullocks, say at Rs. 170 a pair, = Rs. 1,360. Take the working age of a bullock as low as 5 years and allow 20 per cent. depreciation, *i.e.*, Rs. 272—making a total of Rs. 1,572 for six months' working, or Rs. 262 per mensem, or annas $10\frac{3}{4}$* per acre per mensem. To do the same class of work with coolies using hoes or kodali forks it will cost at least Rs. 3 per acre per mensem, as it is a physical impossibility for less than six coolies to dig up an acre of land in a day, in fact Rs. 4 per acre would not be an exceptionally high cost.

A disc plough should also last longer than one year, if well looked after and oiled daily, as I have one which has been in constant use for eleven months, and it appears as if it would last another two years at least.

General.—Another advantage the ploughs have, is that they turn the soil, whereas hoes and forks do not do so to the

* The actual cost of cultivation—including depreciation as here estimated—has proved during the recent dry season to be As. $11\frac{1}{2}$ per acre over an area of nearly 2,000 acres.

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same extent, nor do they crumble the soil so well. Also coolies cultivating with hoes or forks require close and much more supervision than do ploughs, and there is much more likelihood of ground being scamped when done with hoes or forks. At present the only disadvantage disc ploughs may be said to have is that they damage the roots ; so do hoes or forks but possibly in a lesser degree ; but if a dry mulch of 3 or 4 inches is kept on the surface, the roots will naturally go deeper into the soil, which is kept moist owing to this blanket or mulch of dry soil, and little or no injury will be done. Ploughs naturally do best work on gently undulating or flat land, but steep slopes may be ploughed satisfactorily by ploughing across the slopes. Above ground, slight damage is sometimes done by the ends of the yoke striking the tree, but this can be avoided by cutting off the ends of the yokes as short as possible. Unfortunately, I have at present no figures to show to what extent cultivation increases growth and yields here in Burma, but we do know that, owing to this system of cultivation in Australia and America (dry farming as it is called) hundreds of thousands of acres of land have been made to yield crops of wheat, rye, sorghum, etc., that compare favourably with yields in the humid regions of both these continents. Speaking of yields the older trees on this Estate have been tapped daily since September, 1910, with the exception of a half day in the rains 1911 when 4″ of rain fell, and the yields are now as good as ever they were. During 1912, records have been kept of the yields from $7\frac{1}{2}$ acres containing trees aged from $5—9\frac{1}{2}$ years and the yield was 407 lbs. dry rubber per acre ; and this year's yields promise to exceed last. If the manuring of rubber estates eventually has to be done, good and frequent tillage or cultivation will largely reduce the manure bill and delay the day when fertilisers will be needed.

In conclusion, I am of the opinion that from June to September Estates in Burma should be weeded fortnightly, the weeds being just cut off on the surface. In October a deep forking : November a digging with hoes, and then, for the rest of the year disc ploughs.

TRANSPLANTATION OF RICE IN CHHATTISGARH.

BY

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THE cultivators of the Chhattisgarh Division in the Central Provinces have a bad reputation as tillers of the soil. There are several causes to account for this low standard of efficiency. The country was for centuries ringed in by wide stretches of hill and forest which formed a serious impediment to all communication with the outside world; and this condition of affairs continued till as late as 1889 when the first railway line was carried through the tract. There is a large population of *chamars* in the Division who are noted for their thriftlessness. The local breed of cattle is so small that the draught bullocks are not sufficiently strong to cultivate the soil properly. These cattle get very little stall-feeding and the grazing being extremely poor they satisfy their hunger by devouring the field crops: there is a universal custom by which all the cattle of the village graze together, over the fields and waste lands alike, from December till June and much difficulty is therefore experienced in saving the seedlings of the nursery beds for the rice area that is being transplanted each year.

The population suffers much from malaria during the rains and early cold weather: cultivators subject to chronic malaria become lethargic and their work suffers in consequence. The now extinct *lakabhata* system of land re-distribution has left each cultivator with a number of scattered plots of land in the

cultivated area of the village instead of a concentrated area This further handicaps any attempt at the introduction of intensive methods of cultivation, which would be possible if each cultivator's area were consolidated.

A farming community working under such adverse conditions is naturally opposed to the introduction of any improvements which demand more energy, intelligence and skill. They are mentally and physically incapable of changing their methods all at once : they must needs be led by easy stages from that lower standard of farming with which they are content at present, to the higher standard which involves new ways of doing things and which therefore demands intelligent effort. But as the existing standard of intelligence is also low, one must in a case of this kind base all instructions on actual demonstrations conducted in the villages themselves. This has been done : the ryots in thousands of villages in Chhattisgarh have during the last six years been shown how to transplant their rice.

With the limited number of Agricultural Assistants at our disposal it would have been impossible to have done instructional work in several hundreds of villages each year, had not another device suggested itself, *viz.*, to employ as instructors a superior type of intelligent and literate ploughmen recruited in districts where agriculture is more advanced. These instructors are designated Kamdars. This scheme for the employment of Kamdars who should serve the purpose of instructors in new methods of farming has been tried in Chhattisgarh for the last five years and has proved to be a very sound and practical one. These men at first serve for a time on the Raipur Experimental Farm where they get into touch with our methods. This is necessary, as the work for which they are mostly required is the transplantation of rice and the cultivation of cane, and though they may have had experience in both, still they have much to learn. They have for instance to learn to transplant single seedlings instead of bunches since seedlings are transplanted in bunches wherever transplanting is practised in these Provinces.

The advantages to be gained by employing these skilled Kamdars for demonstration work are—(i) that being men of cultivating castes they are more in touch with the ryot, (ii) that they work with their own hands and are therefore more effective as instructors than our assistants who, being in most cases of a non-cultivating class, are physically less adapted to the practical side of this work, and (iii) that nearly all our Kamdars have been recruited from villages in the rice tract, and therefore stand the climate much better than do our trained assistants of the higher castes recruited from the towns.

By steady work on demonstration lines the Department has in six years got an area of 16,000 acres transplanted where this method of cultivating rice was formerly unknown. Crop experiments, carried out in the villages from 1909 to 1911 by our Agricultural Assistants in collaboration with the leading landholders concerned, showed the following average *increases per acre* in favour of transplantation :—

Year						lbs. of paddy.
1909	...	...	...	...	...	687
1910	...	...	...	...	...	556
1911	...	...	...	...	...	693

As the accuracy of these figures had been questioned by certain influential malguzars who were opposed to transplantation, arrangements were made by the Deputy Commissioners in the current year to conduct these experiments.

The outturn, as recorded by the Assistant and Extra Assistant Commissioners who were entrusted with this work, shows that in the eleven villages in which the experiments were carried out transplantation accounted for an average increase of 1,052 lbs. of paddy per acre, while in 5 villages where a comparison was made between the very best transplanted and the very best broadcasted plot, the transplanted plots gave an average increase of 2,204 lbs. of paddy per acre.

We may take it that the yield of irrigated paddy can be increased by transplantation to the extent of one-third, and that the average increase for a period of several years would be some

way between 500 and 1,000 lbs. per acre. If we take even the lower figure, which in terms of money is at present prices worth about Rs. 13, it follows that the Department has in this division been the means of increasing farming profits of rice cultivators by approximately Rs. $13 \times 16{,}000 = 208{,}000$ in one season. It has at the same time reduced the seed rate for the transplanted area from about 80 to 25 lbs. per acre ; so that by transplanting 16,000 acres 880,000 lbs. of paddy have been saved.

NOTES.

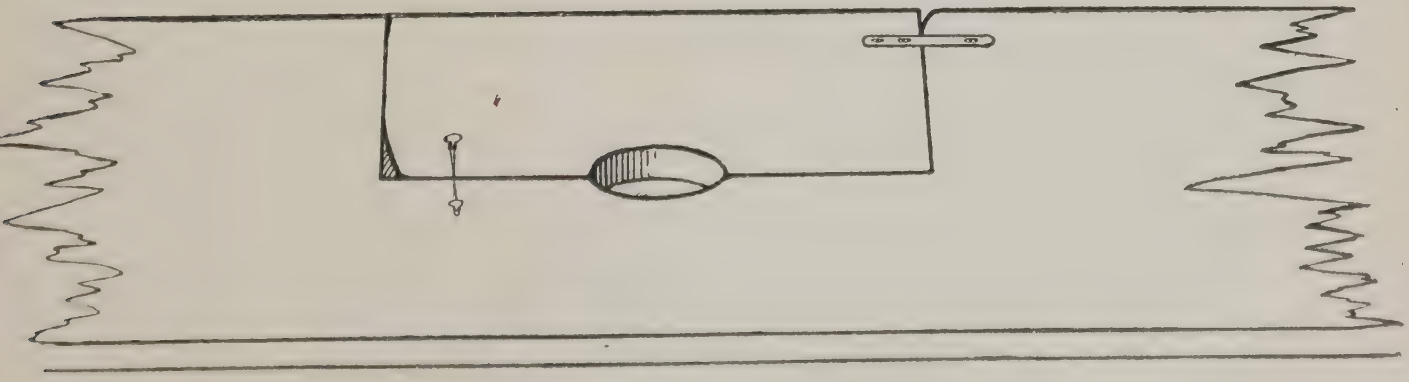
Restrictions on the Importation of Nursery Stock into the United States.—In accordance with the Plant Quarantine Act of August 20th, 1912, the Secretary for Agriculture of the United States of America has issued regulations, which have the effect that, after July 1st of this year, Indian nursery stock will be admitted into the United States only for experimental purposes and in limited quantities. For such importations a special permit will be required.

The term "nursery stock" includes all woody plants and parts of plants, as well as seeds—except field, vegetable and flower seeds.

The text of the Act and of the Regulations has been published in the Supplement to the *Gazette of India* of April 5th, 1913.

* * *

A Plant-holder.—The sketch below shows a plant-holder recently made at the Agriculture College, Coimbatore, in reply



"Plant-holder."

to an order received from the Manager of an Estate under the Court of Wards. The contrivance is intended to hold the

young plant or tree securely and vertically while it is being planted. The construction is simple :—A plain board about six feet long, nine inches wide, and one and a half inches thick is taken. In the centre is bored a hole one inch in diameter, and, including half the hole, a rectangular piece is cut out as shown in the sketch. This piece moves on a pivot, and can be swung out to receive the tree, which is then held firmly in the hole. The piece is fastened in by a piece of string passing round two pegs. For smaller trees or when trees are delicate, a piece of cloth may be wrapped round the stem until the desired diameter is reached.—(R. CECIL WOOD).

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PESHAWAR AGRICULTURAL SHOW.—The Annual Show of the North-West Frontier Province Agricultural Department was held on the Peshawar Agricultural Station on April 15th and 16th, and was attended on each day by over 3,000 agriculturists, some of whom came from over the border.

Competitions and demonstrations provided an extensive programme, including ploughing with both English and country ploughs, digging, and the use of the Planet Junior Horse Hoe—besides sports and livestock classes.

Competition in the events was keen, and the quality of the work performed was excellent. The ploughing was especially good, the furrows of 200 yards length being in some cases worthy of competitors in good English matches. The Pathan digs in English fashion with a good opening and a full-sized spade, and seventy-five men competed in this match. The work of the men who reached the final, was remarkably good and the prize-winners were chosen with difficulty.

In the year 1905 the Planet Junior Hand Hoes were practically unknown in England, and gardeners at home would have been much surprised to see how rapidly and deftly the thirty-three frontiermen adjusted their hoes, and sped up and down the long nursery lines, in weeding, cultivating, earthing up, etc.

Entries in the poultry classes were rather poor, but good fowls were shown and the success of this part of the show is assured for the future.

The Rajah Plough, the Meston Plough, the new American Lever Harrow, the Punjab Chain Harrow, the American Ring Press Roller and several other minor implements were at work, and were watched by critical groups of zamindars during the show, and the farm buildings were examined and discussed freely. Agricultural produce, cases of insects, etc., were shown in the farm museum.

The samples of English wheat and barley of which crops were in ear on the farm were especially admired, and some beautiful samples of cotton from the Imperial Cotton Specialist and from the Economic Botanist, Punjab, attracted much attention.

The sports competitors were all too numerous for the events of one short afternoon, and the games were hurried. Only three men succeeded in poising the weight (Mugdar) above their heads. But this is not surprising—the writer of this note could just raise the log off the ground.

The Hon'ble the Chief Commissioner had intimated that he would visit the show, but he was absent settling a threatened tribal disturbance on the border. Colonel C. B. Rawlinson, C.I.E., Revenue Commissioner, Mr. Mackenna, I.C.S., Agricultural Adviser to the Government of India, Mr. Barton, I.C.S., Judicial Commissioner, Mr. Bolton, I.C.S., Deputy Commissioner, and several Civil and Military officers visited the show. A short but violent duststorm arose just when the show was over, and prevented Mrs. Rawlinson from distributing the prizes. On the evening of the 15th, full 300 agriculturists were entertained to dinner and "tamasha" and visitors from a distance were entertained during their two days' stay at the farm.—(W. ROBERTSON BROWN.)

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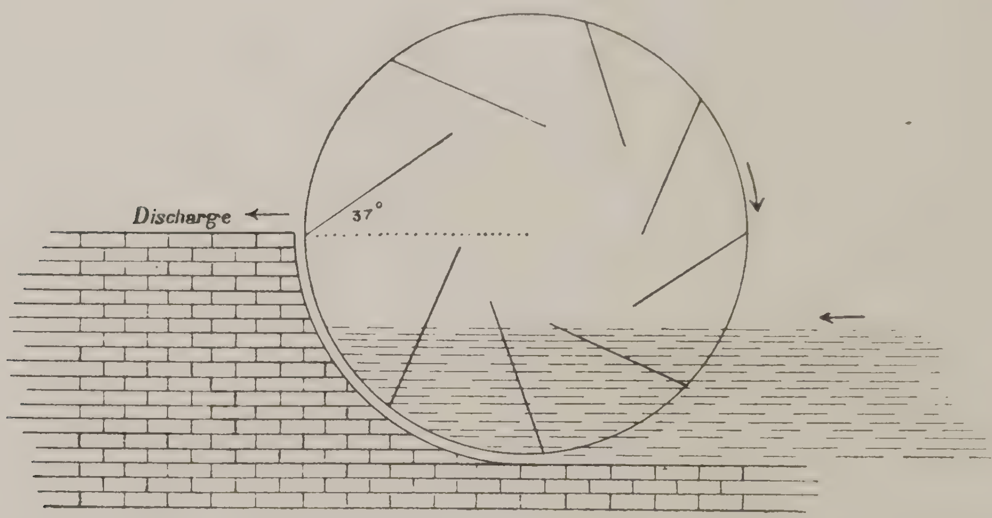
AN EGYPTIAN WATER-LIFT.—A very useful water-lift for low-lift canal irrigation has recently been received from Egypt. It consists of two circular pieces of iron on an axis about 15 inches

apart. These two wheels are connected together by a number of vanes set on at an angle of about 37° to the radius—as in the drawing.



The whole thing revolves in a close fitting masonry basin. It is geared to run at a slow speed and the one I have is worked by one bullock. The wheel discharges the water at the height of its own axis as in the drawing.

This is by far the best machine that I have tried for low-lift irrigation.—(A. E. PARR.)

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PLANTATION CROPS.—Owing to recent 'booms' in the rubber, tea, coffee and coconut industries and the stir created by the negotiations of the Levers with the Liberian Government for control of a large area for the growing of coconut and other tropical products, it is being increasingly realised that there is an almost virgin field open to the intelligent application of capital to tropical agriculture.

The facts appear to be that, in order to enable plants to take full advantage of the favourable conditions of temperature and powerful sunlight prevailing in the tropics, a proportionately great extension of the plant, in air and soil, is necessary—with the result that economy in tropical agriculture lies in the growth mainly of 'plantation' crops such as sugarcane, banana and other fruits, tea, coffee, rubber, etc., the cultivation of which

requires an amount of capital and security proportional to the initial expenditure on deep cultivation and the length of time for which the plantation occupies the ground before coming to profit.

But capital and security are comparatively recent bed-fellows among the inhabitants of warm climates, while the discomforts of life in the tropics for natives of cooler climates, have hindered the intelligent employment of capital by them in the moister regions where the best results are obtainable. Hence the field is still open.

Meanwhile Agricultural Colleges in India are turning out a large number of highly educated young men for whom there is no visible means of subsistence outside Government service. In the growth of ordinary crops, they cannot compete with the rayat—who is fully alive to the advantages of any improvement introduced in the cultivation of such crops, and so realises the full value of his labour on his own land, and will not work elsewhere for any wage that pays the employer who can only grow the same crops in the same way.

It is therefore only by the judicious use of capital and special knowledge that the educated Indian can hope to make farming pay. Does not the cultivation of plantation crops offer exactly the opening that he requires?

The graduate of an Indian Agricultural College, with a good technical education, should be able, with a comparatively small stock of capital, to compete with the European planter—who has all the disadvantages of an alien, and who will not live in a tropical climate except in return for a relatively high rate of interest on the capital invested in his education and on his plantation.

At any rate the present profits are undoubted, and the outlook appears to shew an ample field for both.

From this point of view the systematic investigation of the potentialities of such capitalist's crops, and instruction in the technicalities of their cultivation and disposal, might well form one of the main lines of work in Agricultural Colleges.

One of the more obvious subjects for such investigation is the wild date palm which flourishes wherever rice is grown, and which seems capable of development as a sugar producer on a much larger and more important scale.*

But there must be many other such woody plants of known importance, besides those already commonly grown in plantations, the economics of the systematic cultivation of which would repay local scientific investigation.

* * *

Coconut Cultivation has been the subject of several recent abstracts in the Bulletin of Agricultural Intelligence and of Plant Diseases issued by the International Institute of Agriculture, Rome (notably in the issues for September, 1912, and January, 1913) which condense into a very small space an enormous amount of detailed information on costs, methods of cultivation and manuring, and utilisation.

Estimates of the capital cost, per acre, of plantations, vary from between £12 and £16 for a plantation of 2,500 acres, to £32 for clearing and planting one of 500 acres.

The cost of production of copra in Ceylon appears to be under £7-10 per ton and the price about £22, leaving—on an estimated production of about 15 cwts. per acre—a profit of £10 per acre, for rent and interest on capital, when in full bearing.

* * *

Sugar from Nipa Fruticans.—In a recent Memoir Mr. H. E. Annett says of the Nipa palm:—"This plant grows in low-lying lands by the sea in the Sunderbans, Chittagong, Burma and the Andaman Islands. An alcoholic drink is made from it and I understand a small amount of sugar also. In the Philippine Islands it is used to a considerable extent for sugar making and alcohol production."

The following extracts are from a paper by Mr. H. D. Gibbs of the Bureau of Science, Manila, read at the Eighth

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* *c.f.* The Date Palm Sugar Industry, by H. E. Annett, Memoirs of the Department of Agriculture in India, Vol. II, No. 6, Chemical Series.

International Congress of Applied Chemistry, and since printed in the "Louisiana Planter":—

"Since the Nipa is the only palm which promises to be of any great commercial importance as a producer of sugar sap, no others will be considered here.

"It is an erect, stemless palm, the leaves and inflorescences rising from a branched root stock, the leaves pinnate, 3 to 10 meters long. The inflorescence starts from near the base of the leaves, erect, brown, 1 to 1·5 or 2 meters high, bearing numerous sheathing spathes, and both male and female flowers. This palm grows only along the mouth of tidal rivers in low tide lands subject to overflow of brackish water as the tides rise each day, and it will not thrive in localities where either fresh or sea water alone is available. It reproduces itself and in many localities extends its growing area, encroaching upon the sea. Nipa swamps of considerable size and importance occur in a number of the provinces of the Philippines. Swamp lands, subject to daily overflow by the tides, to the uninitiated would appear to be of no value, but this palm, growing in great abundance in these localities, gives a profitable crop when properly exploited.

"Since the Nipa palm sends its inflorescence up from the base, and hence is near the ground, the flower stalk is conveniently situated for the gathering of sap. Four years after planting the seed, it bears fruit, but it is not tapped for its sap until the fifth year. Some time after the fruit has formed, the stalk is cut across near its top, usually just below the fruit, and each day a thin slice is removed to keep the wound fresh and to facilitate exudation. The sap, as it flows from the stalk, is clear and transparent, almost colorless, and very sweet to the taste. It is collected in small receptacles, usually once a day, and transported in boats to the distilleries. In some districts palms, which are to-day in a perfectly healthy and thriving condition, have been known to have yielded sap on a commercial basis for the past 50 years. The industry is in many respects capable of improvement, which would lead to greater profit. * * * *

"The Nipa palm sap is probably the cheapest raw material now being utilized for the production of alcohol and alcoholic beverages. The industry is confined to the Philippine Islands, where it reaches considerable magnitude, over 90,000,000 litres of sap being produced yearly, and distilled in pot stills, continuous process stills and modern rectifiers. The pot stills produce a beverage varying in composition from 20 to 55 per cent. alcohol, the continuous process stills, alcohol of about 50 per cent. purity and the modern rectifiers, 93 to 96 per cent. spirits. One of the distilleries now in operation is producing 93 per cent. alcohol at a cost of less than 0·04 dollars (United States currency) per litre.

"Sugar is not produced in commercial quantities from the sap of the Nipa palm, but all indications point to the possibility of creating a profitable industry of considerable magnitude. A conservative estimate of production is as follows:—2,000 palms per hectare yield 86,000 litres of sap, containing 12 per cent. recoverable sugar, equivalent to 10,750 kilograms of 96 per cent. centrifugal sugar.* An equipment corresponding to a 500-ton sugar mill can be kept running for 180 days of the year on the sap from 750 to 1,000 hectares† of Nipa lands, and should produce annually about 9,000 tons of 96 per cent. sugar.

"The cost of refining will probably be approximately the same as for cane-sugar, for, owing to the absence of bagasse, fuel will have to be purchased, opposed to which is a saving due to the absence of crushers. The sap arrives at the mill in the same condition as the juice of the sugar-cane after the addition of the lime.

"In order to inhibit inversion of the sucrose of the juice, the collecting vessels must be coated with a thick mixture of lime and water before being placed in position to collect the sap droppings from the cut stem. Sap has been found to undergo no change in 10 days when treated in this way.

"The refining of this sap will require, with the exception of the crusher, the ordinary equipment of a sugar mill, and at

* Over 4 tons per acre

† 2,000—2,500 acres.

present I am strongly of the opinion that more profit is to be made from the Nipa lands through the establishment of sugar refineries than distilleries. I fully appreciate that claims which never have been realized have been made for the profits to be derived from the use of other palms, *Arnega saccherifera* and *Caryota urens*, in Java and India, for sugar production on a commercial scale attractive to the investment of European and American capital. However, in the case of the Nipa, many of the difficulties encountered with other palms do not exist. Some of the points of special advantage to the Nipa are as follows :—

"The swamps now exist in a state ready to bring them into active production merely by thinning, or, in the case of the swamps employed in the alcohol industry, this work is already well under way ; many large areas are not now put to any use and are to be had for a small investment ; the plants reproduce themselves and it is probable that each plant is capable of producing for more than fifty years ; the flower stems are close to the ground and the work of gathering the sap is quickly and easily performed ; the producing plants grow very close together and the production per hectare is large ; transportation of the sap is cheaply accomplished through the numerous waterways, and may be still further reduced by the construction of pipe lines.

"In conclusion I must point out that while these estimates are the results of accurate laboratory and field investigations they must be substantiated on a small factory scale. If no unforeseen difficulty is encountered, I believe splendid returns will accrue."

The conditions under which this palm grows in the Sunderbans, would seem to be worth investigation by capitalists.—(A. C. Dobbs.)

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The Sterilisation of Seeds.—Numerous methods are in use for destroying the micro-organisms which occur on or in the coats of seeds. The most general method consists in washing the seed

with an antiseptic, such as corrosive sublimate. A new process, which appears to give yet more satisfactory results, is described by Messrs. Pinory and Magron in the *Bulletin de la Société Botanique de France* (Vol. 59, 1912, page 609). This process, which has been employed also by others, consists in immersing the seeds in commercial hydrogen peroxide. According to the observations of the authors cited, hydrogen-peroxide is efficacious in destroying micro-organisms and produces no harmful effect on the seeds, even though the latter be soaked in it for many hours. Messrs. Pinory and Magron state, moreover, that hydrogen-peroxide exercises an accelerating influence on germination. Peas treated with the re-agent began to grow a day and-a-half before similar, untreated seed, and seed of *Orobus tuberosus*, treated previously with peroxide, germinated in 8 days—as against 28 days taken by untreated seed. These facts, if they prove to be generally true, are of considerable importance, not only from a scientific and theoretical point of view, but also from that of practice. To give but one illustration, the seeds of many grasses germinate with extreme slowness : if they could be made to germinate in the course of a few days, not only would time be gained but loss from birds and ground animals would be reduced.—*The Gardeners' Chronicle.*

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Coffee Manuring on a Scientific Basis.—We take the following letter from the *Planters' Chronicle*, the official organ of the United Planters' Association of Southern India—as illustrating the advantages of seeking technical advice in cases where it is proposed to remedy marked deficiency of cropping power by manuring.

" I think the results obtained from 3 years' cultivation and manuring according to a scheme proposed by our Scientific Officer, Mr. R. D. Anstead, should be of interest to all readers of the *Planters' Chronicle* interested in coffee—and, I may say, of advantage. Like many other fellow-planters, year after year I applied manures, usually nitrogenous, and in the usual style.

My 50 acres of bearing coffee on one Estate, and 100 acres on another, replied to my best efforts with crops of 5—6 tons on the former, and 14—15 on the latter. From 1902—1910 the former averaged 5 tons, and the latter 14½ tons for 8 years. The manures applied averaged 4 cwts. per acre, consisting mainly of poonac, with bone added occasionally, and in other years fish. The cost worked out to about Rs. 20 per acre and I thought I was doing the places well. The Estates looked well and year after year I looked for the bumper that never came! If I got anything like a decent crop (4—5 cwts. per acre) the following year it dropped to 2 cwts. In parts of the Estate the trees had a "cabbagy" look. Failure began to pall on me, and the arrival of our Scientific Officer made me say to myself, "why not begin all over again, get my soils analysed thoroughly well, and seek Mr. Anstead's advice?" This I did, sending 4 samples to Mr. Alfred Gordon Salmon, Fenchurch Avenue, E.C., who did the analyses very thoroughly, and charged £5-5-0 per sample. I sent these analyses to Mr. Anstead and asked his advice. He took every trouble in working out a 3 years' scheme,——or rather 2 years, and, after seeing the results last November, he was able to advise for another year. I accepted his advice without question. Before giving the scheme he asked a number of questions *re* rainfall, elevation, aspect, etc., and what I was prepared to spend per acre. To the latter I replied, Rs. 25, *plus* cartage. This worked out eventually to about Rs. 32 per acre, or an increase of Rs. 12 to what I had been spending. My crop went up, on the 50 acres, from 9 the previous year to 10 tons, and from 10 to 18; on the 100 acres, from 9 the previous year to 38, followed by 21. I therefore, on the 150 acres, spent Rs. 1,800 more on manures (which was equal to about 1½ tons of crop), and for this increase my crop doubled itself. This year I am expecting (with anything like good rain, which has not come yet, April 7th!) 18—20 tons on the 50 acres, and 30—35 on the 100 acres. If this comes off, and I see no reason why it should not with good rain, I shall average 15 tons for 3 years off the 50 acres, and 30 tons off the 100, against 5 tons for 8 years, and 14½

tons. The whole aspect of the Estates has changed and parts which were "cabbagy" are now vigorous, with a good spread and long spiky close knotted wood. Parts which have just given 8—10 cwts. an acre are scarcely feeling it, and will give 6—7, while other parts which have just given 6—7 are doing the same again. A neighbouring Estate carrying out a scheme on the same lines is having good results also, after a succession of heart-burning failures. Readers will say "yes, you just happened to hit good seasons, wait and see!" I am open to wait and see, and meanwhile instead of a deficit every other year which is far too common on most Estates, I can show handsome profits for 2 consecutive years, and see no reason why I should get a deficit again, provided I carry on manuring and cultivation in the sound way recommended by our Scientific Officer, whose excellent article on manuring, in the *Planters' Chronicle* for January 25th most of us must have read. In addition to my crops increasing, the quality of the bean has vastly improved also. Last year one lot topped the market, and the rest also sold well. Previously the coffee from these Estates used to be in the same boat as many others and realized very ordinary prices. The report, since I started manuring on the lines laid down by Mr. Anstead, is invariably good, and the liquor "exceptionally good."

(Sd.) P. M. WILKINS.

REVIEWS.

The Cotton Worm in Egypt, by Gerald C. Dudgeon, F.E.S.—A paper originally contributed to the British Section of the International Association for Tropical Agriculture and subsequently printed as a special article in the Bulletin of the Imperial Institute, has been issued separately under the above title. In it the author gives a very useful account of the history of the cotton worm (*Prodenia litura*) and incidentally a history of the development of cotton growing in Egypt. A summary is given of the complete life history of the insect as worked out by F. C. Willcocks, which is very similar to the life history of *Prodenia* in India. The insect is of peculiar interest because it is one which was present in the country before the cotton crop was of importance, and seized upon the newly introduced crops which flourished at a time when other food was scarce. A detailed account of the occurrence of the insect in the early years of the development of the cotton industry is given, and the gradual recognition by the authorities of the seriousness of the pest and the measures adopted for combating it. The first method which was tried with any great measure of success was picking and burning of egg-masses and larvæ, and although this did not always meet with success, it is clearly pointed out that the failure was more due to inefficiency of organisation than to the method itself, and that a campaign on these lines organised and carried out by the new Agricultural Service proved successful.

An extremely interesting point is the occurrence of a disease caused by a micro-organism (*Microsporidium polyedricum*) which does great execution among the worms, and is apparently indigenous. Another point of extreme interest to Indian cotton growers is that, although the same insect occurs in India as a

pest of tobacco, etc., yet it has in this country never turned its attention to cotton, the most important Indian cotton pest being the cotton boll-worm, which directly attacks the cotton bolls, whereas the cotton worm of Egypt mainly attacks the leaves.

The author also includes an account of the regulations issued by the administrative authorities at various times, and shows that such methods can, when carried out by a competent staff, effect a great deal and prevent much loss. At the end of the article a brief summary is given of the report of the Commission appointed by Lord Kitchener to consider the cotton worm and the cotton boll-worm pests of cotton, and of the measures suggested for combating them. An interesting chart is also given showing the yield of cotton and the severity of the cotton worm attack from 1890 to 1912.—(A. J. G.)

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WE are indebted to Babu Jamini Kumar Biswas, Superintendent of the Rangpur Tobacco Farm, for a copy of his book "Tamakar Chash" (printed at the College Press, 117-1, Bow Bazar Street, Calcutta. Price, Re. 1-8).

The book, which is written in Bengali, contains 136 pages. It deals with the cultivation and curing of tobacco for ordinary use in India and for cigar and cigarette making. The first three pages are devoted to the history of tobacco--its discovery in Cuba in 1492, and its introduction into Europe and Asia. Pages 6 to 14 describe the efforts of Government and private persons to introduce exotic varieties of tobacco into India.

The language in which the varieties of tobacco are described on pages 21 to 28 is too technical to be understood by plain people and could be suitably replaced by ordinary Bengali.

The outturn per acre in Rangpur is stated by the author on page 78 to be from 15 to 20 maunds—or 10 to 12 *kahans* per bigha, and on page 89 he estimates the value of the outturn at 32 *kahans* per acre worth Rs. 6 per *kahan*, making a total, after adding Rs. 2 as the value of leaves rejected at the time of pruning, of Rs. 194 per acre. Allowing Rs. 116 for total expenditure a profit is shewn of Rs. 78 per acre.

The reviewer's experience in Tirhoot would indicate that this figure is too high. The profit in the latter district is given in a recent leaflet on the subject published by the Department of Agriculture, Bengal, as Rs. 20 per acre, but allowances must of course be made for variations in price and quality.

On the whole the book is a good one and should be useful to Bengali tobacco growers.—(N. C. C.)

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THE INDIAN FOREST RECORDS, Vol. IV, Pt. III. USEFUL EXOTICS IN INDIAN FORESTS BY R. S. HOLE, F.C.H., F.L.S., F.E.S. PRINTED AT THE GOVERNMENT PRESS, CALCUTTA. Price As. 4 or 5*d*.

WHAT promises to be a useful series of monographs has been inaugurated under the above general title in the Indian Forest Records.

An introduction of 19 pages, devoted to a discussion of the value of exotics generally and the necessity for careful choice and preliminary trials, will well repay perusal—particularly by those to whom the mere casual importation of seed of desirable plants appears to be an easy and rapid method of rural economic development.

The subject of the first of these monographs is *Prosopis juliflora, DC.* the Mesquit Bean, a form of which has been successfully introduced into Sind where, at Miani near Hyderabad, it has spread spontaneously and saved the Monument Garden from the inroads of shifting sands.

The pods provide a useful fodder in such desert regions.—(A. C. D.)

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DEPARTMENTAL PUBLICATIONS.

THE first annual report of the Agricultural Stations of the North-West Frontier Province (printed by Messrs. Thacker, Spink & Co., Calcutta) has recently been issued. The work recorded relates chiefly to experiments in the introduction of new

implements, crops, and varieties of crops and fruits. European introductions appear to have a better prospect of success in this far Northern corner than elsewhere in India,— among those that promise well being rye grass and some English varieties of cereals. Even blackberries, imported from France in 1911, have borne good fruit. Twenty-two acres are planted with fruit trees at Taru. Several early varieties of peaches have been introduced, which it is hoped will enable Peshawar growers to market this fruit fully a month earlier than at present. Superior varieties of grapes and oranges are also being experimented with.

A variety of the Mesquit bean (*c.f.* above, p. 305) has done well at Peshawar and is being tried on a large scale at Dera Ismail Khan.

An unwelcome introduction is berseem dodder, which is almost invariably imported with the seed of berseem from Egypt. A recent abstract in the Bulletin of Agricultural Intelligence and Plant Diseases issued by the International Institute of Agriculture, Rome (January, 1913), indicates that this dodder is a specific variety which has been named *Cuscuta ægyptiaca* and it would seem advisable to take special precautions to raise clean seed of berseem in India while it is still possible to keep this dodder out

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THE Central Provinces Agricultural and Co-operative Gazette (printed at the Deshasewak Press, Nagpur, Annual subscription Re. 1) continues to provide interesting reading for the large number of its subscribers.

Besides shorter notes and notices, the December and January issues contain articles on Sugarcane cultivation in India by Mr. McGlashan and, under the title of Agriculture and Co-operation, an account of the important conference of Agricultural Associations held at Akola, in November, at which it was decided to establish "Co-operative Unions" for the maintenance of pure seed of cotton and other crops.

A lecture by Major Baldrey, on cattle breeding, has been appearing serially since February, and will be followed by a second having special reference to the cattle of the Central Provinces.

The notes of the Registrar of Co-operative Societies give an insight that is of more than provincial interest into the practical working of these societies in the Central Provinces, and are supplemented by interesting accounts of the famous Jena glass works "A Factory that owns itself," and of "Raiffeisen —the Founder of Village Banks," in the February and March issues respectively.

THE Bombay Department of Agriculture has issued as a Bulletin (No. 54 of 1912) a note on steam ploughing by Mr. Musto of the P. W. D., recently Agricultural Engineer in the Bombay Presidency (printed at the Government Central Press, Bombay. Price annas 10 or 11*d.*)

While on leave in England in the autumn of 1911, Mr. Musto, on his own initiative, spent 5 weeks investigating the subject of mechanical power cultivation, and the bulletin may be taken as an authoritative exposition of the present economic value of the various available systems. A steam plant is only recommended for deep ploughing of large areas, and particularly for the eradication of the strong *Hariah* grass which can only be got rid of by turning up the soil to a depth of some 16 inches.

Briefly, the author's conclusions are overwhelmingly in favour of the simple system of drawing tillage implements backwards and forwards, between two engines on opposite sides of the area to be cultivated, by means of cables. This is known as the double engine system. The engines move step by step alternately along headlands some 440 yards apart, cultivating the land between them.

The chief disadvantage of the system is the heavy initial cost of the smallest efficient plant, which comes to about Rs. 40,000—and will plough about 8 acres a day of hard black cotton-soil, to a depth of 16 to 18 inches, and 20 acres or more to half that depth. The cost per acre, however, if the machinery can be kept employed for 130 days in the year, is estimated by Mr. Musto at less than Rs. 15 in the former case, and less than Rs. 6 in the latter.

Two or three such plants are about to receive a trial in India.

THE Burma Department of Agriculture has issued a Bulletin (No. 8 of 1912, price annas 12) on Cotton Pests in Burma. It contains a short account by Mr. K. D. Shroff, Assistant Entomologist, of 14 pests, with suggestions for minimising the damage done by them.

THE Journal of the Madras Agricultural Students' Union is issued quarterly from the College at Coimbatore, the subscription being Re. 1 a year. The 2nd issue, dated January 1913, contains, among other notes of local interest and articles, a short account of the Madras Agricultural Stations and the objects aimed at in their work up to the present time. It is proposed to follow this up, in future issues, with a series of "Farm Notes" summarising the work of the Stations, and drawing attention to any experimental data which may have been evolved.

This should prove a useful current review of the experimental work of the Madras Agricultural Department, and ought to attract the attention of agriculturists in that Province to the work of the Agricultural Stations.

A paper entitled "Agriculture and my Experience on the Working of my Farm" read at the Madras Agricultural Conference in July, 1912, by Mr. Vengail Krishnan Nayanar, a landowner of N. Malabar who was for some time a student of the College at Coimbatore, is one of several interesting appendices to the account of that Conference begun in the previous issue of the Journal under review.—(A. C. D.)

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TROPICAL AGRICULTURIST.—We are asked to state that the "Tropical Agriculturist" has been purchased by the Ceylon Agricultural Society—who are now sole proprietors—and is obtainable from the office of that Society at Peradeniya. The issue for April 1913 is an interesting one, and contains as a supplement the report of the Committee appointed by the Board of Agriculture, Ceylon, to arouse public interest in the question of a College of Tropical Agriculture and to point out the advantages of Ceylon as a site for such a College.

RED SPIDER ON JUTE.

THE RED SPIDER ON JUTE

(Tetranychus bioculatus, Wood-Mason.)

BY

S. MISRA, B.A.,

1st Assistant to the Imperial Entomologist.

The [illegible] in experimental plots and in the fields is brought about by a small phytophagous mite called the Red Spider or the "Spinning mite," belonging to the sub-family Tetranychinae, Family Trombidiidae, Order Acarina. It is [illegible] briskly moving about [illegible] active and [illegible] variety [illegible] whitish [illegible] which it spins over itself [illegible] against the inclemencies of weather. It injures the leaves by repeatedly puncturing them and sucking out the sap through the apertures thus made by the aid of the pharyngeal pump with which it is provided.

Like most other injurious insects it wastes a greater quantity of plant sap than what is actually required for its sustenance. It is probably due to this fact that the infested leaves of the jute plant turn a deep copperish [illegible] a greater quantity of sap is run to waste than is actually taken into the body of the animal, with the result that the superfluous sap, coming in contact with the air, undergoes a change and imparts a [illegible] colour to the affected leaves (Plate XXXII), especially the apical leaves. By examining the punctures under a microscope it is evident that the external openings of the [illegible]

EXPLANATION OF PLATE XXXII.

THE RED SPIDER ON JUTE (*Tetranychus bioculatus*, Wood-Mason).

Fig. I.—An affected Jute plant ... ...
Fig II.—Female red-spider ... ... Dorsal view. × 120
Fig. III.—Male red-spider ... ... Dorsal view. × 140

[Figs. II and III have been taken from Mr. Wood-Mason's report on "The Tea-mite and the Tea-bug of Assam."]

THE RED SPIDER ON JUTE.

(*Tetranychus bioculatus*, Wood-Mason.)

BY

C. S. MISRA, B.A.,

1st Assistant to the Imperial Entomologist.

THE discoloration of the jute leaves so frequently seen in experimental plots and in the fields is brought about by a small phytophagous mite called the Red Spider or the "Spinning mite," belonging to the sub-family Tetranychinæ, Family Trombidiidæ, Order Acarina. It is deep scarlet in colour and is easily seen briskly moving about the lower surface of leaves. It is very active and seldom remains at one place feeding for long. It invariably remains on the lower surface of leaves under a thin whitish web which it spins over itself, possibly as a protection against the inclemencies of weather. It injures the leaves by repeatedly puncturing them and sucking out the sap through the apertures thus made by the aid of the pharyngeal pump with which it is provided.

Like most other injurious insects it wastes a greater quantity of plant sap than what is actually required for its sustenance. It is probably due to this fact that the infested leaves of the jute plant turn a deep copperish green. By repeated punctures a greater quantity of sap is run to waste than is actually taken into the body of the animal, with the result that the superfluous sap, coming in contact with the air, undergoes a change and imparts a peculiar colour to the affected leaves (Plate XXXII), especially the apical leaves. By examining the punctures under a microscope it is evident that the external openings of the orifices—

which often coalesce owing to a number of spiders having punctured at about the same spot—soon harden on exposure and prevent free circulation of the sap in the leaves, which in consequence curl over and become extremely crisp.

In young plants the nymphs and adults of the spider are mostly present on the tender apical leaves, which become crisp and discolored. The growth of the young plants is thus retarded, and the crop appears stunted; the affected plants begin to send forth side shoots, and the after effect is that the crop, instead of being a valuable one, from the point of view of fibre production becomes useless.

Besides Jute, the Red Spider is also found on Cotton, Castor, Mulberry, Orange, Indigo, *Trumpheta neglecta*, *Urena lobata*, *Hibiscus ficulneus*, *Hibiscus penduriformis* and *Hibiscus abelmoscus*. In the case of castor, when the crop is badly infested the leaves turn pale yellow and become unfit to be served to Eri worms (*Attacus ricini*, Boisd.). The spider confines its attention to the tender apical leaves, and when these become crisp and leathery in consistency, owing to the absence of sap, it leaves them and wanders about in search of fresh plants. It may then be seen running down the stems and webbing up a thin film, at the roots of young plants, to facilitate its passage over clods and other declivities in the ground. Unlike jute, the castor leaves do not turn coppery green, but become pale yellow and drop off prematurely. In some cases, if the crop is specially vigorous in growth, it is able to withstand the attack better than one which suffers from weak growth. It has further been observed that the castor plants reserved for the Eri worms and allowed to stand on the ground during the hot months, when the Red Spider is at its worst, suffer much more than those which are sown mixed with other crops or grown as a fringe round sugar-cane fields, as is generally done in the United Provinces.

The Red Spider has been under observation since 1909, when its attack on jute was noticed for the first time. Ever since, its progress has been watched, and a note made of its alternative food-plants. During May-June 1910 it was bad on castor and last

year when a series of plots were laid down it was found that it was as bad as it was in 1909 when it was first noticed. Last year the spider was found to hibernate in the adult stage on castor leaves, near midribs, veinlets, toxic glands and other depressions on the leaves. As no jute was then available, the observations and trials were mostly confined to castor, which was reserved on the Pusá farm for the Eri worms, but it is hoped that the observations made on castor will hold good for jute also. This year it was found to pass the winter in the adult stage on the lower surface of castor and *Hibiscus abelmoscus* leaves, as well as below clods and fallen leaves below plants. The adults remain inactive till the middle of February, after which, with the first rise in temperature, they copulate and commence laying eggs. Warm, dry weather being especially favourable to its development, the spider breeds prolifically during April, May and June. For this reason, during last April, the leaves of *Hibiscus abelmoscus* were so badly infested that with the webbing on them, the plants appeared white from a distance. The lower surface of the leaves was thickly covered with a thick deposit of silken webbing many layers deep. The plants looked sickly, and were about to die when a heavy shower of rain in the beginning of May cleared off the spiders and made the plants look fresh and healthy again. The past five years' observations have strengthened the conviction that rain is fatal to the development of the spider, either colonies of them are clean swept off or very few of them are left over to continue the progeny. If however warm sunny weather continues to prevail for some time after a rainfall, the spider again develops and the plants suffer consequently. It is for this reason that the discoloration of apical jute leaves, so prominent in the beginning, either entirely disappears or is considerably lessened during a spell of rainy weather, but again becomes prominent as soon as there is a break in the rains.

So far as has been seen the spider remains invariably on the lower surface of Jute, Castor and *Hibiscus abelmoscus* leaves. Only in one instance was it seen to be present in numbers on the

upper surface of castor leaves, but this was an exceptional case. when the crop had suffered much from adverse climatic conditions. Ordinarily, the adults, the day after reaching maturity, begin to couple and lay eggs. Each female lays from 80 to 90 eggs. The female does not lay all the eggs in a cluster, but she continues to lay them scattered all over the lower surface of the leaves. She does not lay all the eggs in one day but continues to do so for over a week. When all the eggs have been laid, she becomes lethargic and dies soon after. The eggs are laid near midribs and veinlets, mostly in shallow depressions on the lower surface of the leaves. In some cases the eggs were seen covered with a few silken strands, but in most cases there was no covering at all over the eggs. The female, when about to lay eggs, raises her abdomen, the head and the thoracic region being brought low to facilitate extrusion of the egg. In this posture she remains for a few seconds, when a pellucid white globule is extruded and dropped on to the leaf below. In this way two or three or more eggs are laid, then the female turns round and exudes fine silken threads which she glues to one side of the depression. She then moves forward and attaches the other end to the other side of the depression. The egg, as laid on the leaf, is a pellucid white object which seems almost too large to be laid by a creature of the size of the female. It is an oblate spheroid, flatter at one end than at the other. It is thinly covered with whitish filaments which are imperceptible to the naked eye. Prior to the emergence of the nymph it turns pale brown. The empty shell remains attached to the lower surface of the leaf unless it is mutilated by the passing of a large number of nymphs and adults over it or is blown off by the wind and the rain. Four to five days after the laying of eggs, the nymph emerges. It is then pale yellow with only three pairs of legs. Immediately on coming out of the shell it begins to feed and to spin a thin webbing within which it may be seen moving about with ease. The object of spinning a web over it seems to be protective, as on very cold days the dew drops are to be seen adhering to the webbing and not thus coming directly

in touch with the nymphs or the adults. A few days after, the webbing is strengthened and the nymph is then out of danger. It then draws its legs together under the sternum and moults, to come out as an adult. The female is ·45 m.m. long and ·27 m.m. broad, nearly semi-circular in shape and deep scarlet in colour. The rostral sheaths, mandibles, maxillary palpi and the legs are shiny pale brown. The two pairs of eyes are represented by shiny spots edged with black. The male is ·32 m.m. long and ·20 m.m. broad. It is lighter in colour than the female. Its body is broad anteriorly and narrowed posteriorly. As in the female, the rostral sheaths, mandibles, maxillary palpi and the legs are light, shiny pale brown. The two pairs of eyes are represented by little shiny spots ringed with black.

The male is easily distinguished from the female by the shape of its abdomen. In the former the abdomen is rounded anteriorly and narrowed posteriorly, whilst in the latter it is rounded anteriorly as well as posteriorly.

The whole life-history occupies 8 to 9 days. It will thus be evident how the spider overruns the crops. It lays a fairly large number of eggs which mature into adults after only eight days. Thus starting with a fertilised female on the 1st March, there will be three millions and a half of spiders ready to reproduce by the end of the month provided in the first brood the number of males and females was equal and that the climatic conditions were favourable to the development of the adults. From the above it will be clear that if any measures are to be adopted to check the ravages of the pest, they should be promptly adopted in the beginning to prevent it from firmly establishing itself on the plants. When once established, it is not only expensive and troublesome but simply a waste of time and energy to cope with a pest that reproduces itself so fast.

The nymph, as soon as it is out of the shell, begins to suck the juice of the castor leaf with the result that the spot where four or five of them congregate to feed soon turns pale yellow, gradually turning into deep yellow. With the increase in the number of spiders the paleness extends until the whole leaf turns

pale yellow and prematurely falls off. Prior to the falling of the leaf the spiders leave it *en masse* and either establish themselves on other healthy leaves on the same plant or wander about and ultimately establish themselves on other healthy plants.

Five predators have hitherto been observed to prey upon the mite. One is a small brick-brown Ladybird beetle (*Clanis soror*, We.) about the size of a split Khesari seed (*Lathyrus sativus*). Its larvæ and adults may be seen in numbers on the lower surface of leaves infested by the mite. The adults, as well as the grubs of the Ladybird beetle, may be seen actively running about in search of their victims. Another is a small black *Staphylinid* beetle which may be seen in numbers below infested leaves with its abdomen doubled over its back. The third is a small shiny black Coccinellid or a Corylophid beetle about the size of a split mustard seed. The fourth is a species of *Scymnus* and the fifth is *Brumus suturalis*, Fabr. But all these predators, even when they are present in numbers, are unable to appreciably reduce the number of the mites in a plantation. Rain has a decidedly prejudicial effect upon the mite, either whole colonies of it are clean swept off the leaves or only a few are left to breed, and if it continues for some time, especially during the hot months of May and June, there is little likelihood of the mite being bad during the year. The effect of rain on the spider was observed during the beginning of the hot weather in 1910, and the conclusions then arrived at have been substantiated by the following two years' observations. An extract from the monthly observations book will bear out the point.

April 1912. * * * * *

From the beginning to the middle of the month, the Red Spider was rapidly on the increase in the ratoon castor plot on the farm at Pusa. The plot was sown during May 1910 and half of it was cut back during the following June. The spider appeared on the leaves by the middle of February 1912, in isolated places, but by the beginning of March it began to breed and disperse. By the middle of April a majority of the leaves were badly infested, so much so that some of the leaves in the middle of the plants had prematurely turned pale with very minute yellow spots on them. They either became very crisp or thin and papery. Their undersides looked as if covered with a thin film of white, made up of the silken webbing and the empty egg-shells adhering to the leaves. On the 17th April there was a light shower of rain and ·05" was received between 7-15 and 8-30 P.M. On the 20th April there was another light

shower accompanied with strong wind and thunder. On the 21st April a heavy shower of rain accompanied with hailstones of the size of a small walnut fell between 7-30—9-30 P.M. On the 23rd April when the leaves were examined they were found to harbour very few spiders. On some previously badly infested leaves there was no trace of the spider excepting the empty egg-shells, a few nymphal exuvia, and a whitish film showing thereby that the spiders had previously infested the leaves ....

This year, too, the same thing was noticed. In the beginning of May the leaves of *Hibiscus abelmoscus* were badly infested with the mite. The leaves were thickly covered with webbing freely interspersed with fine particles of dust, with the result that the plants from a distance looked blighted. Below the web, myriads of mites in every stage of development were present, so much so that within a square centimetre of leaf-space hundreds, nay thousands, of mites were present. The effect of the presence of so many tiny scarlet creatures on the leaves could better be imagined than described, and it was no wonder if the plants had withered prematurely, had it not been for the timely arrival of a shower of rain on the 8th May when ·44″ of rain was registered. This was followed by another shower the following day when 1·14″ was registered. An examination of the leaves on the 10th May showed that there were very few nymphs and adults left over to multiply and reproduce the colonies. From these observations it is clear that if the plants are sprayed with sufficiently cold water in the early stages of infestation, much good is likely to accrue. In nurseries and plants in pots much good is done by blowing the fumes of burning sulphur on to the affected plants with a smoker such as is used by bee-keepers. But this treatment is out of the question in the field, where much good is done by either dusting the plants with flowers of sulphur or spraying with sulphur mixed with Crude Oil Emulsion. The sulphur to be used must be precipitated or sublimed sulphur. It is no good using Roll sulphur, even though it may be ground very fine, as it clogs the nozzles of the spraying machines. To obtain satisfactory results the plants should be sprayed with :

Crude Oil Emulsion	½ pint.
Flowers of Sulphur	2 ozs.
Water	4 gallons

Later on, if the mites are still found on the plants a second spraying is to be given, but with double the quantity of sulphur, which should be thoroughly incorporated with the emulsion by hand, water is then to be slowly added and the whole brought up to four gallons. To obtain satisfactory results in the field it is essential to spray the plants with force pumps, as these send forth a sufficiently strong and continuous shower of spray which penetrates the silken webbing within which the mite remains feeding. With the ordinary Bucket pumps without air-chambers and syringes this cannot be done.

During July 1909, a series of experiments were made against the Red Spider and it was found that to spray an acre of very badly infested jute 40 pints of Crude Oil Emulsion and 5 lbs. of flowers of sulphur were required to keep the crop free of the pest. One out of a long series of experiments would illustrate the above figures :—

			Area	Acre.
Plot No. 24	...	...	,,	$\frac{1}{30}$
,, ,, 25	...	...	,,	$\frac{1}{30}$
,, ,, 26	...	...	,,	$\frac{1}{30}$
,, ,, 27	...	...	,,	$\frac{1}{30}$
,, ,, 28	...	...	,,	$\frac{1}{30}$

Formula :—

Crude Oil Emulsion	...	...	$\frac{1}{2}$ pint.
Flowers of Sulphur	...	...	2 ozs.
Water	...	...	4 gallons.

Machine :—

Gould's Standard Spray Pump mounted on cart.

Time :—

Two hours. (For purposes of calculation, half the day has been charged).

Labour & Cost :—

		Rs.	As.	P.
Two men @ Re. 0-3-3 a day, $\frac{1}{2}$ day	..	0	3	3
Two men @ ,, 0-2-0 a day, $\frac{1}{2}$ day	...	0	2	0
Crude Oil Emulsion, 8 pints, @ 40 pints for Rs. 6-8-0	...	1	4	9
Flowers of Sulphur, 1 lb., @ Rs. 6-4-0 per cwt.	...	0	4	5
TOTAL	...	1	14	5

SOME PROBLEMS OF RICE IMPROVEMENT IN BURMA.

By

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THE commercial aspect of the Burma rice trade has been fully dealt with in the Note* published last year by Mr. Noël Paton, the Director-General of Commercial Intelligence. In that Note methods of transportation, storage and handling are described and criticised, and the question of relation of prices to the present system of milling and marketing investigated, while at the same time the dominant position of Burma in the world's rice trade is emphasised. From the statistics given it appears that although Burma is only fourth among the provinces of India as regards rice acreage, and second in the proportion of rice to her other crops, her exports constitute about 75°/₀ of the total shipment from the Indian Empire, while she contributes 63% of the western world's imports of rice, against 1·3 per cent. from India proper. These facts and figures make it clear that rice improvement must form a large part of the activities of the local Agricultural Department.

The aim of the present paper is to state the problems of rice improvement which, primarily at least, the Agricultural Department is called upon to solve and also, as far as is possible at present, to indicate the means of solving them. To begin with, it is obvious that the nature of the problems to be dealt with must depend on the demands of the milling community, and we

* "Burma Rice." Superintendent of Govt. Printing, India, Calcutta, 1912.

cannot do better than quote from or give a 'précis' of a paper read by Mr. Menzies, Manager of Messrs. Bulloch Brothers & Co., Ld., Rangoon, at the first Agricultural and Co-operative Conference in Burma held at Mandalay in July 1911. Mr. Menzies, as spokesman of the Rangoon Rice Millers, and with the approval of the local Chamber of Commerce, presented to the Conference the views of the milling community on this subject. In the course of his paper he briefly described the milling process as follows :—

"Rough or Cargo rice consists of grain partly husked, say 20 per cent. unhusked to 80 per cent. husked, but of course the percentage of unhusked grain can be reduced if required, at an enhanced cost. Rough rice is shipped largely to Europe and, in smaller quantities, to America and Australia, the greater portion being milled into white rice for human consumption. Protective tariffs and methods of treating the grain peculiar to each country doubtless account for the export of so much rough rice.

"Cleaned or white rice is rice fully husked, and has also the outer skin of the grain milled off. There are five qualities recognized in the Rangoon rice trade, and these vary in whiteness according to the colour of the grain and milling they receive, as also in the proportion of broken to whole grains, say from 25 per cent. broken in the best qualities to 55 per cent. in the lowest qualities.

"Briefly, the process of milling consists of cleaning the paddy of all extraneous matter so far as is possible by means of sifts. The husk is then removed from the grain by a system of hullers, fans and sifts in which process a certain amount of breakage occurs, varying according as the grain is regular or irregular in size, more particularly as regards length. The husked rice is then milled to the required whiteness in cones, in which process a proportion of the grain is broken and what is known as rice bran is taken off. After being put through polishers to remove any particles of a floury nature, the surplus broken rice is sifted out until there remains only the quantity recognized in the

quality of rice being produced. The proportion of broken rice and bran varies with the quality of rice, the percentage of course being highest in the best qualities.

"The broken rice is sifted into several grades, varying in size and colour. Some are shipped to India, Ceylon and the Straits Settlements for human and animal consumption, and some to Europe where they are manufactured into foods, starch, etc.

"Rice bran is the outer skin of the husked grain reduced in the process of milling to a mealy substance. After leaving the cones it is cleaned on special machines, packed in bags, and as a rule shipped to Europe, where it is largely used in the manufacture of cattle foods."

The author of the paper then went on to specify the main essentials of good paddy from a miller's point of view. Briefly these are as follows :—

(1) A bold grain of regular size.—This condition is necessary because in the milling process described above no practical method has yet been devised to separate grains into grades of different size and accordingly the hullers and cones have to be adjusted to a certain mean, with the result that grains which in size are below the mean are left unhulled and appear as paddy in the milled sample, whereas those which are over the mean are broken in the milling process, thus seriously lowering the value of the sample milled. The term "bold" will be explained later: roughly speaking it means a roundish grain as opposed to a long thin one, thinness being correlated with fragility and breakage.

(2) The second point on which stress is laid is uniformity of colour. The presence of red grains, so common in Burma rice, is greatly to be deprecated. On this point Mr. Menzies remarks :—

"Every rice-consuming market in the world is protesting against receiving either rough or cleaned rice which contains more than an extremely small proportion of red grains. No amount of milling will eradicate the red tinge from even the better qualities of cleaned rice, while in rough rice and the lower grades of cleaned rice the red colour is only too obvious."

In addition to these objections to red grain on the part of the consumer there is also the miller's objection that to attempt to remove the red coat entirely in the milling process means the breakage of a large proportion of the white grains. Red grain, in short, is objectionable for the same reason that grain of uneven size is objectionable.

(3) The third point deals also with the same all-important questions of breakage. Awned rices are objected to because the presence of awns tends to increase breakage in the same way.

From the above considerations it is at once apparent that rice-improvement problems are very different from those of wheat or any other cereal. The former is husked and polished only, and, with certain exceptions, the grain is eaten whole. The latter is ground into flour with the result that the question of breakage has no significance, but, on the other hand, the all-important question of 'strength' in the flour at once arises. This is a chemical question which has no parallel, at least not under present conditions, in the case of rice. The two sets of problems may be summarily contrasted by saying that the main problems of wheat improvement are baker's problems and their significance is based on chemical considerations; the problems of rice-improvement are miller's problems and are, for the present at least, more or less of a physical nature. If there is one matter in rice-improvement under Burma conditions which compares in importance with the 'strength' question in wheat, it is essentially the question of 'breakage' of the grain in the milling process.

Let us now consider these questions in some more detail and with special reference to the methods to be employed for their solution at the Experimental Stations. As we have noted above, the main points, *viz.*, grain shape, uniformity of grain, grain colour, and absence of awns, have all special reference to the question of breakage. At the same time the demand for white grain is also clearly a consumer's, as well as a miller's demand. So far as the European consumer is concerned, it apparently does not much matter what the shape of the grain is, at least we have not at

present any information on the point. What we are explicitly told is that he objects to broken samples and red grain.

Taking now in order the several essentials of a good rice we may examine these a little more closely.

I.—Grain Form.

The demand is for a "good bold grain." By boldness is clearly meant an approach to the spheroidal state as opposed to the cylindrical. Clearly what we wish to determine for our selected parent plants is a numerical factor or co-efficient which will adequately express the character involved and which while differing widely in value in different varieties or races will be approximately constant for one and the same variety or race. In this way only can different rices be classified and valued with a high degree of precision. It is clear that the geometrical idea which comes nearest to the rice grain is the ellipsoid of three unequal axes. The cross section of this through the thickest part is an ellipse the area of which is proportional to the product of the two minor axes, *i.e.*, of the breadth and thickness of the grain. Now it is clear that within certain limits and for practical purposes the grain may be considered as becoming rounder and plumper in form if this area increases in size while the long axis diminishes. Hence using the letters l, b, t, to denote length, breadth and thickness of the grain we may conveniently take the expression $\frac{100\ bt}{l}$ as an index, to express the measure of boldness possessed, the multiplication of 100 being to get rid of fractions. That is, we use as our index the quotient obtained by taking one hundred times the product of the breadth and thickness and dividing it by the length. The above index values, however, depend on the unit of measurement used, *i.e.*, whether m.m., fractions of an inch, etc. It would be more in keeping with general usage if the index taken had been $\frac{100\ b \times t}{l^2}$ which would give an abstract number independent of our unit. The two methods, however, lead to the same degree of discrimination and the former has the advantage of having a multiplication less than the latter.

These three measurements length, breadth, and thickness can easily be made to a sufficient degree of accuracy by means of a good screw gauge micrometer and they supply us at once with two very important series of numbers, *viz.*, a series to express relative volumes or size, got by multiplying together these three magnitudes and another series to express "grain-form" or "boldness" as described above. There is, of course, no necessary correlation between the two sets, a very large grain may not be a bold one, and a very bold grain may on the other hand have a very small volume. The amount of discrimination obtainable for "grain-form" depends of course on the accuracy of the instrument used.

Working with a micrometer which read to $\frac{1}{100}$ mm. and taking three widely divergent types of rice grain as an illustration, the following "grain-form" indices were got as means of the determinations.

No.	Class.	Sub-Class.	Grain-form index.
1	Non-glutinous	Slender ... ... Large	64
2	Ditto	Long ... ... Large	95
3	Ditto	Short ... ... Large	110

From this we see that differences of as much as 70 per cent. may be found with reference to the character of "boldness" or plumpness in the grain.

It will be seen that the "grain-form" numbers increase with the boldness and are proportional to it, enabling us at once to classify quantitatively any series of races with respect to that character.

Recently Kikkawa* has used this exact measurement of the grain as basis for a systematic classification of cultivated rices, supplementing actual measurements by volumenometric estimation. The result is a classification admirably adapted for commercial purposes.

II.—Breakage.

There can be no doubt but that breakage in milling depends on more than one factor. In Java† it was noted that there seemed to be a dependence between breakage and the appearance of the husked grain, and that grains of a glassy nature through and through gave less breakage than grains which were white and mealy in whole or parts. From physical considerations, however, it is obvious that the shape of the grain must have most to do with the degree of breakage—hence the desire of millers for 'bold' as opposed to slender grains. Breakage, like grain-form, should be capable of being estimated as a physical constant for any variety, the obvious method being to subject the rice to some degree of pressure and then take the broken grains (measuring either by weight or capacity) as a percentage of the whole. In Java the ordinary country pounding mill was used : in some mills in Burma a rough idea of the degree of breakage of a sample is got by passing a roller over some rice spread on a notched board in order to husk the grain. The husked rice is then put into a bag and the bag beaten against a wall, the number of blows being the same for all samples. The paddy before being rolled is measured in a measuring glass and then the amount of broken grains after beating so measured. To estimate this factor it will probably be found most convenient to improve on the latter method by using a roller of constant weight and furnished with a handle for manipulation, so that the personal factor may as far as possible be eliminated in performing the tests. This would be pushed over

* "On the classification of cultivated rice" Reprinted from the Journal of the College of Agriculture, Imperial University of Tokyo, Volume III, No. 2, Tokyo, September 1912.

† "Onderzoekingen Omtrent Rijst en Tweede Gewassen" by J. Van der Stok, Batavia, 1910.

the rice by the operator, who will, of course, exert no downward pressure. The pressure will thus be fairly constant in each trial, and if, experimental errors are taken into account, the method should prove well enough adapted for comparative tests. It is to be noted of course that the percentage of break got by this method would bear no relation to that got in large milling tests : the result would be comparative only. Incidentally it may be noted that, in the Java tests mentioned above, the break varied from 30 to 80 per cent.

III.—Grain Colour.

The colour of the husked grain may be either white, red or purplish black. A peculiarity of Burma rice, however, is that although any sample of village rice examined between Mergui and Myitkyina will be pretty sure to show a considerable proportion of red grains, black grains are uncommon. The reason is that most black grained rices are glutinous, are generally reaped early, and are used as delicacies and for immediate consumption. Hence contamination of white by black becomes a matter of some difficulty. The grain colour question, then, resolves itself into the elimination of the red. That red acts as a simple dominant to white has been proved by artificial crossing, in Java, where the ratio 3 : 1 was obtained in the F_2, and this appeared also from some tests made at the Hmawbi Station by the author during the last growing season. Hence we may suppose the red to contain a factor which the white lacks. The red colour is in the outer layers of the grain only and does not extend to the endosperm. It is partially removable in hot water and the water in which red rice is boiled is quite red. Red and white grains are never found on one and the same plant : when one grain is red all are red, and similarly with white. A red plant can usually be detected by an experienced cultivator by the darker appearance of the glumes, especially when they are wet with dew ; but a too facile dependence on the eye alone is a bad principle on which to perform selection. The real test is to remove the husk, when

the colour of the grain becomes at once apparent. It is quite clear that, if the crop consisted of a simple mixture of pure reds and pure whites, ordinary selection, supposing it to be done carefully, would enable a cultivator at once to purify his crop. The question arises, to what extent cross-pollination plays a part in the matter, for as no trace of such crossing is left in the grain, during the year of the cross such grians will be passed over by a cultivator as white, but will give rise to red plants in the succeeding year. If crossed grains were red in the year of cross, *i.e.*, if xenia as found in maize took place in rice, there might be less difficulty. This phenomenon, however, is not known to take place, and even if it did, would probably be difficult for an ordinary cultivator to detect.

Accordingly, in order to estimate the extent of a cultivator's difficulties, *i.e.*, to determine the approximate extent of undetectable contamination of white by red we are under the necessity of testing for cross-fertilization and red-white heterozygotes in ordinary field crops. The test made by the author was as follows :—From a cultivator's field, known to be growing a mixture of a variety known as red and white Ngasein, 100 heads each of red and white were selected, each head having a grain husked to show the nature of the colour. These heads were sown separately in small raised plots in the nursery, the plots being raised above the water level so that seed could not be washed from one plot to the other till the plants had taken proper root. Watering the seed was done daily, by hand, from the water in the field, until germination took place, and then continued till the young plants were firmly rooted and a couple of inches high. The nursery was then flooded as usual. Each plot was transplanted out in a separate row, giving 100 rows each of white and red. When the plants were ripe every plant in the experiment was examined, by husking the grain by hand, and its colour noted. The results were as follows :—

(1) From the 100 white sowings 2,508 plants resulted, two of which were red.

(2) From the 100 red sowings 3,839 plants resulted, of which 255 were white and the rest red. In all 22 of these red cultures split up as follows :—

Field No. of culture.	No. of red plants in progeny.	No. of white plants in progeny.
1	50	11
4	42	16
7	41	6
8	31	8
13	27	12
36	5	2
37	60	20
38	6	4
39	54	14
42	19	5
46	22	4
47	51	12
55	35	10
59	30	6
66	63	12
70	32	12
78	43	16
83	39	19
87	39	24
92	34	18
93	43	17
99	47	7
TOTAL ...	813	255

Ratio 3·1 : 1.

This result seems to indicate that, as found in Java, red and white are characters showing Mendelian segregation, the F_2 giving a 3 : 1 ratio with red dominant to white. The actual factor for the cross-fertilization in the previous year is accordingly given by the reds arising from white sowings, *plus* a correction for the reds crossed by whites.

The proportion of reds from white was ·08 per cent. But the original seed showed that the total of red grains in the crop was about two per cent. Hence by the Law of Probability the percentage of red crossed by white would be $\cdot 08 \times \frac{98}{2}$ and combining the two results a simple calculation shows that in this particular case the crossing for the previous year must have been about ·16 per cent. between one and one-tenth per cent. of the whole crop. It is to be noted, however, that this

percentage cannot be looked on as more than the result of a particular case and that it varies according to the composition of the particular sample of seed sown. Meantime it is sufficient to note that the percentage of crossing must be so small that from a cultivator's point of view the elimination of most of the red grain should present no trouble. He cannot, however, unless by chance, completely eliminate it. A residuum of undetectable red will always remain. Hence the work of complete purification is one which must be left to the experiment station.

IV.—Awns.

The remarks made above concerning red grain apply equally in the case of awns. The inheritance of awning has been studied in Java by Van der Stok* who found that in cases of highly developed awning the awned variety is dominant to the unawned, but that intermediate forms also make their appearance. In the particular case, where a cross was made between a very short awned variety and an unawned one, the F_1 generation was entirely without awns. This apparently shows that different factors are at work to produce this character.

In Lower Burma awned varieties are not so common as unawned, so that it is quite easy for a cultivator to overcome the miller's difficulty of awning by choosing a variety known to be free from awns. One of the varieties, however, most desired by millers in Lower Burma, known as Bawyut—Midon, and which is at present under study at Hmawbi consists of a mixture of awned and awnless plants. Cultivators say that it produces most awns when the soil is good, and that then the yield is large. What is probably the case is that some samples of seed contain a larger proportion of heterozygotes (awned) than others, and that it is the existence of these, which, by the well known law of the increased vigour of hybrids, accounts for the higher yield obtained.

* "Onderzoekingen."

The subject of awning, however, requires to be studied more thoroughly in order to be better understood.

The effect of awns on the breakage percentage, is, of course, easily uuderstood. The broken awns left, being of different lengths, tend to make the grains irregular in size, with the result described above.

The points noted above are such as occur mainly in consequence of the demands of the trade. It is obvious, however, that they by no means exhaust the list of the problems to be solved in connexion with the rice crop. On the whole they present the easiest part of the work. Over and above them there is a whole series of questions relating to increase of outturn, by improvement of cultivation, manuring, and specific selection for that purpose. This has been put in hand by the laying down at Hmawbi of manurial and cultivation experiments and by the selection last year of several hundred single-ear cultures. The latter aspect of improvement bristles with difficulties, and the work for some time must be experimental and tentative, even to the number of cultures employed. It has for its object an analysis of cultivators' varieties, with a view to discovering whether new "unit species," from the point of view of yield and the desirable characters, can be obtained from them, and whether, with this object in view, any trust can be put on the eye alone or whether purely random selection will have to be done. To ascertain this, 1,000 plants of each of six varieties were planted out 3 feet apart all ways, so that the complete habit of the plant could be seen. Out of these a few of the apparently very best plants were selected and then seed separately saved and labelled. Then a selection of every tenth plant in the rows, good or bad, was done. All these cultures will be sown in rows during the present season and careful weighments made of their progeny, due care being taken to determine the amount of experimental error. This work should form one of the most interesting and important of the aspects of rice improvement.

Another set of serious difficulties arises from the fact that the limiting factor in successful rice cultivation is the water-

supply. To the tyro in rice cultivation, nothing is more striking than to realize that cultivators readily discriminate between rice fields which to his eye are apparently all on the same level. The cultivator who has worked his holding for years knows better, however, and he generally divides his fields into top, middle and low-lying land, reserving his long-lived paddies for the bottom fields and his short-lived for the higher. Hence the Agricultural Department as a rice-improving agency must be in possession of a series of rice varieties which differ in growth period so as to suit different conditions of water-supply, and its problem is to ensure that in other respects, *e.g.*, grain-forms and colour, uniformity, etc., these varieties shall differ as little as possible. Hence classification of varieties must be of a two-fold nature, they must be divided into groups according to their growing period, and each group must be again sub-divided according to the size, shape, and other characters, of the grain. Only in this way can the uniformity which the trade demands be obtained.

When all such problems have been solved at the Experimental Stations, the all-important question of distribution of seed arises, and the policy which the Agricultural Department in Burma proposes to adopt in this matter may here be shortly stated. The Province possesses in many parts a well organized Co-operative movement. Where such exists it is proposed to utilize it in preference to any other system. A cultivator in a Co-operative Credit Society or Union will be asked to become seedsman for his Society or Union, and to set apart his holding for the purpose. He will receive, annually, varieties for trial from the Experimental Stations, and perform the few simple tests necessary for acclimatisation. The approved varieties he will multiply and sell to his fellow co-operators, recouping himself for his labour by receiving an enhanced price for his improved seed. To ensure co-operators the benefit which ought to be got from using pure seed, the Co-operative Credit Department here are organizing Sale Societies by means of which members are enabled to sell to the mills, direct, and on the most favourable terms. To assist Societies to do this work,

a staff of District Agriculturists is at present being trained on the experimental farms. The ultimate object of the Department is to create a real demand for improved seed, and, with this end in view, to introduce, if possible, the idea of the professional seedsman as he is known and appreciated in western countries. The Co-operative Credit Organization seems to afford the best starting point for such an idea and it is probably not looking forward too far to imagine a time when seed businesses will spring into existence here, as in more advanced countries. Much, of course, depends on the active co-operation and assistance of the rice trade itself: it is the demand for improved grain, and the willingness to pay for it at enhanced rates, which alone can set in motion the machinery above described.

THE IMPERIAL BACTERIOLOGICAL LABORATORY, MUKTESAR: ITS WORK AND PRODUCTS.

A REVIEW

BY

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Offg. Agricultural Adviser to the Government of India.

The Imperial Bacteriological Laboratory is situated at Muktesar. It is 23 miles, by a bridle path, North-East of Naini Tal and 13 miles South-East of Almora, so that it enjoys all those conditions of magnificent isolation which are considered desirable, if not essential, for concentrated scientific research.

An interesting monograph, giving a description of the Laboratory, its work and products, written by Major J. D. E. Holmes, M.A., D.SC., M.R.C.V.S., &c., the Imperial Bacteriologist, has just been issued by the Superintendent of Government Printing, India, Calcutta. The monograph gives a simple and readable account of the activities and achievements of the Laboratory: is profusely illustrated and should be read by all who take an interest in the progress of Veterinary Bacteriology in India. The object of the present brief review is to convey to readers of the Agricultural Journal of India an idea of what the monograph contains and the great amount of useful work which is being done at Muktesar. Naturally I shall make frequent use of the actual words of the monograph in the course of this description, and I take this opportunity of making a general acknowledgment to Major Holmes for the free use I have made of his own words.

The monograph opens with a short history of the Laboratory. The first step in the direction of the systematic investigation of the diseases of animals in India was taken in 1890, when Dr. Lingard—who will always be remembered as a pioneer of Veterinary Science in India—was appointed Imperial Bacteriologist in connection with the Laboratory at the College of Science in Poona. Investigation, in the earlier years, was principally confined to the disease of surra in horses. It was found, however, that the climatic conditions of Poona were not favourable for bacteriological research and for the preparation of vaccines and sera, and it was resolved to remove the Laboratory to a suitable site in the hills: Muktesar being ultimately selected. Here work, on a small scale, was commenced in 1895 and has continued on an ever-expanding scale ever since.

By this time the importance of the investigation of rinderpest and measures of prophylaxis had come to the front and, in 1896, the distinguished Bacteriologist, Professor Koch, at the request of the Government of India, visited Muktesar, and demonstrated his bile method of inoculation against rinderpest. During the next few years rinderpest and the methods of preparing a potent anti-serum were the principal interests of the Laboratory. This anti-rinderpest serum having been evolved, the scale of operations was extended. The original Laboratory was completely destroyed by fire in 1899: but a new one was built: and increases of building and staff have gone on as the demand for the products of the Laboratory has expanded. A Branch Laboratory was built at Bareilly to admit of a certain amount of research work being carried out during the winter months and this it is now proposed to enlarge considerably, so as to allow of the continuous manufacture of anti-rinderpest and other sera throughout the year. From 1901 to 1904 the preparation of anti-sera for anthrax and hæmorrhagic septicæmia, of black quarter vaccine and of mallein, was added.

Dr. Lingard held the post of Imperial Bacteriologist from August, 1890 to 1908, when he retired. During his absence on leave (November 1898 to January 1900), Major Leonard Rogers,

PLATE XXXIII.

Main Building of the Laboratory.

I.M.S., C.I.E., held charge of the post. On the retirement of Dr. Lingard, Captain (now Major) Holmes, who had joined the Laboratory in 1901 as Assistant Bacteriologist, became Imperial Bacteriologist, and has held charge continuously ever since except for the period from February to November 1910 when he was on leave and Major F. S. H. Baldrey, I.C.V.D., acted for him.

The post of Assistant Bacteriologist has been held by the following officers :—

Dr. Stephens—April to June, 1898 ;
Lieutenant (now Major) Walker, C.I.E., 1898-1901 ;
Lieutenant (now Major) Holmes—1901-1907, except for a period of deputation in 1904-05, when the post was held by Mr. Montgomery and Mr. Martin of the Civil Veterinary Department ;
Mr. Cross, C.V.D.—1907-1912 ;
Mr. Meadows, C.V.D.—1912.

The numerous buildings which go to make the complete equipment of the Imperial Bacteriological Laboratory are built on an estate which comprises some 7,000 acres. Part of this is a reserved forest which supplies timber for the working of the machinery of the Laboratory, and with reference to which Major Holmes exercises the functions of a Conservator of Forests : the remainder, which is under a farm manager, is required for the maintenance of the large herds of cattle which are required for the work of the Laboratory.

The accompanying illustration gives a good idea of the Laboratory Main Building, which, in addition to the actual laboratory rooms, contains accommodation for the clerical staff, chemical store rooms, record rooms, photography rooms, media rooms, incubator rooms—all thoroughly equipped with the necessary apparatus, and provided with water, gas and electric light. In the main building, also, is located the library, which contains some 3,500 volumes.

The further equipment of the Laboratory consists of sheds for the accommodation of the animals used in preparing the various

forms of serum manufactured: operating sheds, a stable for surra experiments, a stable and *post-mortem* house for glanders experiments, and out-laboratories for anthrax, black-quarter and mallein. All the work connected with serum preparation and investigation, in anthrax, black-quarter and mallein, is carried out in their respective out-laboratories. This prevents the risk of infection by sporulating organisms, and of glanders being brought into the main laboratory, and tends to the general safety.

These buildings are on the west of the main building. On the east side are situated the sheds for the cattle used in the preparation of the rinderpest serum, three operating sheds, a *post-mortem* house, incinerator, stables and dog-kennels.

The Out-Kraals—six in number—are situated from 1 to 2 miles from the Laboratory. These provide accommodation for a reserve supply of animals, and for animals which have been under experiment and are being kept under observation for a long period: as also for the segregation of cattle accidentally infected with foot and mouth disease or any other accidental infection.

In addition to the buildings actually used in the work of the Laboratory, there are a Hospital and Dispensary, a bungalow for the accommodation of visitors, a Public Works Department Inspection Bungalow and a well-equipped Institute for the recreation of the Staff—a boon which is much appreciated in this isolated spot.

In Chapter IV of his monograph, Major Holmes describes the difficulties which beset the Veterinary Departments in India in their attempts to tackle diseases amongst cattle. Treatment by approved methods cannot be forced upon cattle-owners, while, although segregation may be insisted on and disobedience of rules visited with punishment, the areas are so vast and difficult to control that no direct attempt at the eradication of any endemic disease is feasible. Again, even if eradication were possible within British India, there is constant risk of reintroduction of

PLATE XXXIV.

Two of the Rinderpest Sheds.

infection along the frontier lines. In view of these numerous difficulties, the operations of the Veterinary Departments are directed towards the suppression of outbreaks of epizootic diseases as they occur.

In these difficult circumstances, the most effective weapons which the Veterinary Department can wield against the constantly recurring epidemics of disease are *sera* and *vaccines*, and these can only be used when the owners consent to have their cattle treated. It is the highest tribute, not only to the soundness of the recommendations made from the Imperial Bacteriological Laboratory at Muktesar, but also to the patience and care of the district officers of the Civil Veterinary Department, that there is an increasing demand for these various sera and injections.

Research and experiment with these sera and vaccines and their manufacture form the principal work of the Imperial Bacteriological Laboratory at Muktesar: the discovery of these sera and vaccines has completely revolutionised the practice of Veterinary Science. But they cannot effect all things, and disappointment is sometimes caused by an exaggerated idea of the possibilities of these agents and an ignorance of their legitimate application. These limitations are thus emphasised by Major Holmes: and as public attention is apt to fix with much keener criticism on failures than on successes, it is as well that the limitations of the efficiency of these sera should be recorded. The following points, says Major Holmes, should therefore be borne in mind:—

(1) No serum can confer anything more than a temporary protection against its specific disease. The periods for which sera protect vary in different diseases, from two weeks to not more than six weeks.

(2) In using serum, the object aimed at is not so much the preservation of each animal treated, as the control of the epidemic and the prevention of the spread of the infection.

(3) No serum or vaccine will protect every animal treated. Many individuals cannot be immunised, either on account of an intense susceptibility or more frequently from the existence of an intercurrent disease.

(4) The duration of the immunity afforded by a serum or vaccine is not in every instance exactly the same. Some animals are protected for a shorter time, others for a period longer than the average.

(5) Serum gives an immediate protection. With vaccines, the immunity is not established for a few days after the injection. Dead vaccines give a protection for a somewhat longer period than serums. Living vaccines produce an active immunity of long duration (several months to one or two years), but their use is attended with the risk of a small percentage of deaths due to vaccination.

Rinderpest or cattle-plague exacts annually an enormous toll of victims in India, and it is to the combating of this fell disease that the main efforts of the Veterinary Departments of India are directed. An anti-rinderpest serum was first prepared by Kolle and Turner in South Africa and used there with success in 1898: the following year it was manufactured at Muktesar and its use introduced into India.

When it is noted that the object of anti-rinderpest inoculation is to protect healthy cattle at the time of an actual outbreak, by inoculating them and then turning them out together with the infected herd in order that an opportunity of contracting natural infection and a larger immunity may be given, it can easily be imagined that considerable opposition was at first encountered. After a few years, however, the successful results obtained, combined with the patient services of the provincial officers, overcame this opposition, and cultivators now eagerly demand inoculation when an epidemic breaks out. In

consequence, from 1907 to 1910, the maximum output of some 5 lacs of doses was insufficient to meet the demand for serum.

In 1910, improved methods of preparing the serum were discovered—by the application of which in the following year over one million doses were manufactured at the same cost as was previously expended on the manufacture of half that amount.

It may be added that the reputation of the Laboratory, so far at least as the manufacture of anti-rinderpest serum is concerned, has travelled far beyond India, and that large indents for the serum have been received from the Straits Settlements, Egypt and Rhodesia.

But, while the labours of the laboratory staff are, in the main, devoted to the manufacture of anti-rinderpest serum, this does not exhaust their energies. Vaccines and sera are now manufactured for anthrax, hæmorrhagic septicæmia, and *Charbon symptomatique* or black quarter. For the diagnosis or treatment of the diseases of horses, mallein and anti-streptococcic serum are made: and considerable success has been achieved in the treatment of surra by one or other of the following methods:—

(1) Arsenic alone;
(2) Arsenic and Atoxyl;
(3) Arsenic, Atoxyl and Tartar Emetic;
(4) Salvarsan alone; by one or more injections.

The above recapitulation might convey the impression that the Laboratory is merely a great manufactory of veterinary specifics. But this is far from being the case. It is a great centre of veterinary research: the scope of whose efforts will be largely extended when a full scientific staff has been recruited. The finished product is what the public gets, but, to obtain this product, much scientific thought has to be expended: improved methods of manufacture devised: reliability of the specific recommended to be guaranteed: new means of combating disease investigated. An indication of the enormous amount of scientific work done at the Laboratory can be gathered from the record

of the publications which have issued from it, and which are detailed in Chapter III of the monograph.

The monograph is a modest statement of the excellent work which is being done by the Imperial Bacteriological Laboratory on behalf of the great cultivating masses of India, in whose hands are the cattle, the backbone of the agricultural wealth of the country, and we can confidently recommend its perusal to all who have the interests of this class at heart. They will realise that on this side of our work, we are not neglectful of our duties and obligations. That the veterinary profession places some value on the work of the Laboratory is clearly indicated by the fact that the Steel Memorial Medal, for original research in matters pertaining to the veterinary profession, was last year awarded to Major Holmes, the Imperial Bacteriologist.

AMERICAN COTTON IN THE CENTRAL CIRCLE, UNITED PROVINCES.

BY

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VARIOUS opinions have been expressed as to the feasibility of profitably growing a long staple cotton, of the American variety, in the United Provinces, and it seems desirable to place on record the actual results that are being obtained.

American cotton was first introduced into the United Provinces in 1888, and experiments were made with imported varieties at the Cawnpore Farm until 1901. In that year a bulletin was published by the late Mr. Subbiah embodying the results obtained in more recent years. In 1903 some further importations were made, but a remark by the late Mr. Hayman in the Cawnpore Farm report would indicate that the seed issued to cultivators was of the originally acclimatised stock, *viz.*, Upland Georgian. This is, therefore, the probable origin of the cotton now grown under the name "Cawnpore-American." From 1905 an organised effort was made to introduce the cultivation of this acclimatised American cotton on a considerable scale, more particularly around Aligarh but also in several districts of the Central Circle: this was continued after Mr Hayman left India, and four years ago there was a very considerable area under this crop.

But difficulties arose as to the marketing of the produce and the growing of American cotton collapsed.

It need hardly be pointed out that whenever the introduction of a new crop is attempted in which the additional profit to the grower depends principally on the quality of the produce, special arrangements for marketing are essential : this is particularly so in the case of cotton where the preliminary manufacturing process of ginning intervenes before the principal product comes on the open market. There is always a market in India for cotton with a staple of the "middling American" class, but there are not necessarily buyers of the *un-ginned* cotton willing to pay an adequate price.

In a recent article in this Journal, Leake and Parr have pointed out the requisites of the ideal cotton for the United Provinces. It is of interest to see how far the acclimatised Cawnpore-American cotton satisfies these. As regards yield it may be safely stated that the yield is fully equal to that of the best *desi* when both are grown under favourable conditions. Seed of this variety was obtained from two zemindars, last year, who had continued to grow this cotton for four years *on account of its superior yield.**

In 1912 eight acres of this cotton was grown at the Cawnpore Seed Farm, in close proximity to twenty acres of the Aligarh White Flowered selected *desi* (which is an excellent yielder) on land recently taken over from cultivators : the average yield of each was approximately 9 maunds per acre. At Etawah, on better land, and with a rather better season than was experienced at Cawnpore, American cotton yielded 14 maunds of *kapas* per acre and Aligarh White Flowered *desi* 12 maunds per acre.

Ginning Outturn.—In this respect American cotton of the variety referred to above is at a disadvantage compared with the local Indian cottons, since the former gins (in bulk) 31 per cent. lint to *kapas*, whilst the latter usually gins 33 to 34 per cent. and the selected cotton above referred to 38 to 40 per cent. This not

* [The fact that they were able to obtain a fair price for their product from small village spinners (who often do their own ginning) was probably of equal importance.]

only discounts the additional price due to the superior lint but also means that ordinary middlemen, buying on the basis of *desi kapas,* will not handle small lots of American.

Habit.—The American variety requires a slightly longer growing period than *desi* and, save in very exceptional years, must be sown with irrigation, whilst *desi* cotton can be sown either with irrigation or after the fall of the first rains. This unfortunate limitation restricts the cultivation of Cawnpore-American cotton to early sowings in irrigated tracts.

It is obvious from the above that it is useless to expect cultivators to grow American cotton unless a market can be guaranteed.

At the beginning of 1912, the Elgin Mills Co., Cawnpore, came forward and stated that they were prepared to back their statement that there was a market in the province for long staple cotton by guaranteeing to the growers, through the Agricultural Department, a premium of Re. 1-4 per cotton maund (Re. 1 per standard maund) for American cotton in the form of *kapas.* With this guarantee an effort was made to re-introduce American cotton cultivation in villages around Cawnpore. Seed of the old Cawnpore variety was not available in large quantities and Dharwar-American seed was imported. In all a crop of over 120 bales was produced, ginned under supervision and handed over to the Elgin Mills, who financed the whole transaction and took all risks.

With regard to the Dharwar variety it is sufficient to say here that it has been discarded. On the average it has yielded less than the Cawnpore variety, has a lower ginning percentage, is more susceptible to damage by rain when grown on heavy soil, and produces a lint which, if anything, is slightly inferior to the Cawnpore variety. Seed of the latter variety is now available from our own Seed Farm, and sufficient to sow about 600 acres has just been issued and sown.

Quality of the lint.—The statement has frequently been made that American cotton when grown in India rapidly degenerates until it is no better than the ordinary local short staple cotton;

this is quite incorrect. It is quite probable that some degeneration does take place owing to the changes in composition which invariably occur when a mixed crop is grown in a new environment; this degeneration, if it has taken place, is of an entirely different order of magnitude to the difference between Cawnpore *desi* and Upland American cotton.

Through the courtesy of the Elgin Mills we have been able to arrange for comparative spinning trials on a commercial scale between Cawnpore-American, Dharwar-American and imported "middling" American cottons, and they have kindly permitted the publication in full of the results.

"Report on the working of Cawnpore-American Cotton, Season 1913.

Nett weight of cotton	29·43 lbs.
Waste made in Blowroom	4·5%.

Comparative Wrappings of Dharwar-American and Cawnpore-American.

Dharwar-American.		Cawnpore-American.	
Wrappings	Test	Wrappings	Test
25·64	46·33 lbs.	27·77	50 lbs.

Comparative Wrappings of Weft from Mules.

Middling-American.		Cawnpore-American.	
Wrappings	Test	Wrappings	Test
37·03	30 lbs.	37·03	26·16 lbs.

Comparative Wrappings of Twist from Rings.

Middling-American (Imported).		Cawnpore-American.	
Wrappings	Test	Wrappings	Test
23·12	63 lbs.	22·86	58·50 lbs.

General Remarks

"The appearance of the cotton, as we get it, was in almost all ways similar to the American we are getting from Liverpool. Thickness and silkiness of the fibre perhaps 5 per cent. less.

Length of fibre generally equal to our American.

Fineness of fibre, *i.e.*, diameter 5 per cent. to 7 per cent. larger than American.

Strength of fibre only 8 per cent. to 10 per cent. less.

The great fault is the amount of short fibre contained which might be eleminated. This of course means greater loss in the Draw Frames.

Refraction.—This cotton which was run through the same sequence of machines as all our tests lost, as stated, 4·5 per cent. Machines are :

1st Single Crichton Opener combined with small 26″ Porcupine Opener.

2nd Buckley Opener combined with Breaker Scutcher.

3rd Finisher Scutcher.

These machines are all new 1907 to 1910 and are all in good order. Through similar machines our American loses 5 per cent.

The cards, drawing, slubbing, inter and roving frames are all new and in good order, all the comparative tests went through the same machines. In the rovings, mules and rings one tooth only extra twist was put in over and above our ordinary American.

The tests as compared with our work have come out very well, the test even for 22·86 warp being very good.

But it is as a weft cotton we should find it useful especially from 26*s*. to 36*s*. counts. Before using it as a fine warp cotton, the short fibres would have to be eliminated. I am now thinking of a 24*s*. warp.

There is no doubt in this cotton if we could get more of it, we should find it of great assistance especially in the weaving of our fine cloths."

(Sd.) W. VERNON,

Mill Manager,

Elgin Mills Co.

The following broker's valuation received from the British Cotton Growing Association, although of less importance than the practical spinning tests above referred to, is of considerable interest as showing the position this cotton would occupy in the English market. It should be added that the sample sent to Liverpool was taken from the last picking, and was not quite as good as the Elgin Mills' sample, which represented the whole crop.

"2 *Bales marked G. G. & Co., Nos.* 302/3.

No. 302, *Cawnpore.*—Equal to about 'low middling' American in grade, rather dull, staple $1\frac{1}{8}''$, silky, strong but irregular. Value in commercial quantities 6·50*d.*

No. 303, *Dharwar.*—Equal to about 'low middling' American, staple about $1\frac{1}{16}''$. Value in commercial quantities 6·25*d.* Low Middling 6·47*d.*"

From the above report it will be seen that the Cawnpore American grown in 1912—at least 10 years, probably 24 years, after the original importation of seed was made—is within measurable distance of ordinary 'middling' American, and consumers are willing to buy it on the basis of the current price of middling American. This cotton has been seen in bulk by many of the Cawnpore spinners, and the opinion has been freely expressed that the various Cawnpore mills, alone, could annually consume from ten to twenty thousand bales of this cotton, without materially altering their existing machinery. It is not perhaps commonly recognised that the Cawnpore mills import considerable quantities of American cotton every year, as well as large quantities of the long staple Indian cottons, such as Broach. Accepting the provincial average for the outturn of irrigated cotton, the abovementioned quantities correspond to an area of twenty thousand to forty thousand acres, so that there is ample scope for several years' work.

The future of American cotton will depend largely on the price obtainable for the lint. Recently *desi* cotton has been dear—in the opinion of many spinners disproportionately so—and any

fall in the price of cotton is likely to affect the lowest quality most. Five years ago, when *desi* cotton was relatively cheap, it was possible to offer cultivators a premium of two rupees per standard maun d for American "Kapas" and this may easily recur.

There is some margin for improvement in the crop itself. In the above report reference is made to the presence of short fibres: an examination during the past season of a large number of individual plants has shown that while the crop was on the whole comparatively uniform, there were a number of plants present yielding a distinctly inferior lint. In the same way some plants showed a ginning percentage much below the average. It is hoped that by selection, pure types can be isolated and thus an appreciable improvement effected in the uniformity of the lint and in the ginning percentage: due precautions being taken to prevent cross fertilization. In addition, a preliminary examination is being made of some more recent importations.

It should be stated that the writer fully believes that the best prospects of ultimate success lie in the hybrid cottons now being produced by Mr. Leake. The limitations of the American class from an agricultural point of view are obvious, and the present attempt to extend American cotton growing must be looked upon as a *pis aller*. It has, however, certain advantages of permanent importance. There is a demand for a long staple cotton for Indian consumption, and there seems to be every reason for producing it as long as this can be profitably done, an organisation is being established which will be of great value whenever any better cotton is available for general introduction: and the existing *desi* varieties are being partially replaced by a variety which will neither hybridise with the existing Indian cottons nor with any hybrid cottons, of the Indian type, which it may be desired to introduce later. Further, a market is being developed for long staple cotton in the form of *kapas*.

For the current season, the Elgin Mills have again promised to take the whole of the crop; this time with an improved

guarantee of a minimum price with a further additional price on a sliding scale depending on the spot price of 'middling' American.

The writer wishes to acknowledge the generous assistance received from this Company and from Mr. Vernon, and in particular the unfailing courtesy and readiness to assist the Managing Director, Mr. Bevis.

SOME EXPERIMENTS WITH STEAM THRESHING MACHINERY AT CAWNPORE.

BY

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Deputy Director of Agriculture, Central Circle, U. P.

Steam threshers have been in use in India on a few large estates under European management for a number of years, but little has been done towards their general introduction. The opinion has been commonly expressed that they are unsuitable to the country and, even in official publications, the statement has more than once been made that the methods of the country are not likely to be improved on. These statements appear to have been made without serious consideration.

No one interested in the improvement of the general standard of cultivation in Northern India can fail to be impressed by the necessity of introducing mechanical power at some stage to relieve the pressure on working cattle. Commencing with the *kharif* sowings in June-July there is a constant demand on the bullocks throughout the year, terminating only with the end of the threshing season in the following June. This demand they are unable to fully meet, and the result is a lowering in the general standard of cultivation, and a reduced area under the more valuable crops. The general introduction of mechanical power for ordinary agricultural operations on cultivators' holdings is an impossibility at present, on account of their small area. The raising of water for irrigation and the crushing of sugarcane are suitable operations for the employment of mechanical power, but here also the scope is limited.

Threshing is probably the one operation of all others which is badly and uneconomically done by present methods, and being one which could readily be performed by contract naturally suggests itself as a suitable stage for the introduction of mechanical power. Under the present system the whole of the available cattle power is occupied in threshing, from the beginning of April until the middle or end of June, and in many cases threshing and winnowing is not properly completed before the rains commence. As a result, the preliminary preparation of the land for *kharif* crops is not satisfactorily done, and hot-weather cultivation for wheat is practically impossible: in irrigated tracts full advantage is not taken of the canal supply to sow early cotton and early fodder crops; and in sugarcane growing tracts, dependent on well irrigation, where the greatest demand for water occurs in April and May, cattle are occupied in threshing which are badly wanted elsewhere.

Again, the process of hand winnowing calls for a large amount of labour at the hottest time of the year, when labour is also scarce and dear owing to the incidence of the marriage season, and, when all is done, the result is not entirely satisfactory since country-threshed wheat and barley is rarely as clean as it should be and the "*bhusa*" is usually full of dust.

It will be admitted that there is ample reason to justify the attempt to introduce mechanical power for the operations of threshing and winnowing.

Experiments were made at the Cawnpore farm and at the Allahabad Exhibition with various types of hand and bullock power threshers. None of these were a success, for two principal reasons. The amount of power lost in transmission in small bullock power machines is abnormally high, and secondly, a single pair of village bullocks (or for the matter of that two pairs) were quite incapable of continuously working the smallest machine tried. All the machines failed in one important respect, *viz.*, their inability to make *bhusa*. One was, therefore, brought back to the oft-stated general principle that for any operation which can be per-

PLATE XXXV.

formed with mechanical power bullock power is an exceedingly expensive source of energy.

Further experiments were made with a small machine driven with a small oil engine, but here again the results were not satisfactory.

It is highly probable that the limited success of steam threshers in India has been very largely due to incomplete adaptation to local requirements. The machine used in the present experiments is a modification of one specially designed by Messrs. Ransome, Sims and Jefferies and exhibited at work at the Allahabad Exhibition in 1910-11. Important alterations have since been effected as a result of the experiments carried out by the makers expert at Allahabad and subsequently at Lyallpur. A detailed description of the machine would be out of place here, but it may be of interest to outline some of its special features. Most machines recommended for use in hot countries, where the straw is harsh and brittle requiring thorough disintegration before being fed to cattle, consist of the ordinary standard type of thresher with an attachment for straw chopping and bruising. Such machines are not an unqualified success, the capital cost and power required being high compared to the output. The machine illustrated on the opposite page attempts to imitate more nearly the native method of making *bhusa* in which the *bhusa* is made in contact with the grain. It contains two special concaves, fitted with a modified form of peg drum in which the pegs, which are of special design, are arranged helically on the cylinder. The bulk of the threshing is done in the first drum and here also the straw is thoroughly bruised and broken up. In the second concave the threshing is completed and the straw converted into fine *bhusa*. As a consequence of the special arrangement of the concaves a long "shoe" is provided running the whole length of the machine. A further feature of the machine is the elevator to the dresser, in which considerable adjustment is afforded, to ensure clean threshing and the minimum of breakage when working with either bearded or bald wheats. A 30" machine (N. I. L. 30) was used driven by a three nominal horse power, portable,

steam engine capable of developing 12 brake horse power. The following figures were obtained on a whole day's run :—

Actual running time	... $7\frac{1}{4}$ hours.
Time stopped for oiling and adjustments	... 40 minutes.
Time spent on cleaning up	... 25 ,,
Total	... 8 hours 20 minutes.
Time engine was under steam ...	... 11·5 hours.*
Grain threshed	... 82 maunds.
Corresponding weight of bhusa ...	... 183 ,,
Coal consumption	... 7 maunds 16 seers.
Cost of Coal	... Rs. 3-6-0

Best run $26\frac{1}{2}$ maunds in 2 hours = $13\frac{1}{4}$ mds. per hour.
Second best run 21 mds. in $1\frac{3}{4}$ hours = 12 mds. per hour.

LABOUR.

One driver	... Re.	1	0	0	per day.
One stoker	... ,,	0	6	0	,,
One oiler	... ,,	0	8	0	,,
Two feeders @ 0-4-0	... ,,	0	8	0	,,
Four coolies @ 0-3-6 ...	... ,,	0	14	0	,,
One pair of bullocks (stacking bhusa)	... ,,	1	0	0	,,
Total	... Rs.	4	4	0	
Lubricating oil, etc.	... ,,	2	0	0	
Total cost per day	... ,,	9	10	0	
Cost per maund	... One anna ten pies.				

* Unnecessarily long.

The wheat threshed was Pusa 8, grown on land recently taken over from cultivators and not cultivated before the rains. The threshing was clean and the breakage was negligible, though rather more than in the case of Pusa 106 threshed on previous days. (Pusa 8 was found to be "tender," this year both at the seed farm and at the Experimental Farm, and showed a tendency to break, not only in the steam and hand threshers but also when threshed by bullocks in the ordinary way). The *bhusa* was fine and soft and quite suitable for feeding. This *bhusa* has been continuously fed to the farm bullocks, and the general opinion of cultivators and zemindars who have seen it is that it is quite good enough for feeding, although rather longer than the best country *bhusa*, since it is fine, soft and thoroughly crushed.

In subsequent trials the above figures were slightly improved on, and there is no doubt that the machine is capable of dealing with 13 maunds per hour steadily, and of getting through 100 maunds of grain per day, with the ordinary long straw such as is experienced in the irrigated tracts in the United Provinces. On a short run of half an hour, eight maunds were threshed, *i.e.*, 16 maunds per hour. With the shorter straw met with in the unirrigated tracts and in Bundelkhand, a larger outturn of grain is obtainable, since the feeding of the machine is limited by the speed at which it can handle the straw. It should be stated that during the trials the feeding of the machine was left entirely to the farm gang, who had less than a week's training, and the management of the engine and stoking to the native driver. With skilled supervision better results were obtainable, and it was found that the feeding of the machine improved appreciably as the gang gained experience. It was also found that when a small premium was paid to the feeders on the amount of grain threshed, more keenness was shown, and on several occasions we were able to get through 50 maunds in half a day. This reduced the cost per maund to one and a half annas.

The harvest this year was early, and, as the machine was not received until a fortnight after we had finished cutting at the farms, little time was left for district work. The machine was sent on tour in adjoining villages and some quite good threshing was done. A further demand for the machine arose at the end of May and the beginning of June, after some rain had fallen, and much wheat which was too damp to thresh with bullocks was successfully threshed, including some that had been partially threshed by bullocks and which would otherwise have rotted on the threshing floor. Four annas per maund was charged, except in one case where a fixed charge per day was made for threshing wet wheat. Applications for the use of the machine next year have already been received and there is little doubt that it will be fully occupied next season.

It is obvious that steam threshing must as a rule be done by contract, and it is therefore necessary to see how far it offers a fair

investment for capital. The size of the machine is in this case of considerable importance, since in larger machines the initial and running expenses are proportionately lower. On the other hand, transport is more difficult with the larger machine, and a larger supply of raw material is necessary, involving more frequent moves.

As far as the threshing is concerned, it was obvious that unless a 42″ machine could be used, which would permit of the sheaves being fed crossways instead of end-on, little economy would result. A 42″ machine would permit of the use of a small traction engine which would haul the machine as well as thresh, and would materially increase the output in proportion to the working cost. The haulage of such a machine over village roads would be a difficulty however, and, for the present at any rate, there would be difficulty, in villages around Cawnpore, in getting sufficient material concentrated.

The cost of the machine and engine landed at Cawnpore is Rs. 5,000, including the necessary spares; of the machine alone Rs. 2,680. Interest, depreciation and repairs at 20 per cent.* amount to Rs. 1,000 per year. Assuming that the thresher works for 60 days per season, threshing 100 maunds per day, at a gross profit of $2\frac{1}{2}$ annas† per maund, we have receipts of Rs. 937-8-0, so that the thresher would barely pay for itself.

There are two directions in which the above calculation is faulty. Firstly, it is not fair to charge the whole of the interest and depreciation on the engine to the threshing.

During the remaining nine months of the year the engine can be employed in a variety of other work such as cotton ginning and grinding *ata*—two operations for which zemindars are beginning to see the advantage of employing mechanical

* Interest at 6 per cent.
Depreciation on thresher 10 per cent.
Depreciation on engine 6 per cent.
Repairs say 300/—6 per cent.

† *i.e.*, a charge of four annas per maund.

power and which are highly profitable—not to mention pumping and sugar-cane crushing, where an equally wide field exists. Under these circumstances, the interest and other charges on part of our capital are reduced by three quarters, in other words, the machine has now to earn Rs. 662 only before making a net profit, which leaves a reasonable margin.

Again, the charge we have assumed of as. 4, per maund of grain for threshing, is much below that charged in Europe (where *bhusa* making is not demanded), and is much below the cost of threshing by bullock power.

By the ordinary country method five pairs of bullocks at the Cawnpore farm threshed 1,000 lbs. of sheaves in 18 hours, corresponding to about 4 maunds of grain. At present prices for bullock hire (Re. 1 per pair per day) this means Re. 1/4/- per maund *exclusive of winnowing*, which latter operation costs under favourable circumstances about anna one, to annas 2, per maund. In neighbouring villages Re. 1/- per maund is a fair estimate for threshing and winnowing.

Using the Egyptian Norag thresher (which costs about Rs. 40/-) we have been able to reduce the cost of threshing to about one-third, *i.e.*, 7 annas per maund for threshing, *plus* 2 annas per maund for winnowing or a total of 9 annas per maund. Making due allowance for the fact that village rates are lower than those obtainable near a town like Cawnpore, it seems a fair deduction that, once the steam thresher is known, the larger cultivators will be willing to pay 6 annas per maund for threshing and winnowing, especially in view of the indirect benefits which have already been mentioned and which most cultivators realise. At this price threshing is a remunerative undertaking.

At first there will be a number of practical difficulties. Until steam threshing is firmly established there will be increasing difficulty in getting sufficient work during the last month before the rains. The distances from place to place will be disproportionate, owing to the scepticism of the more conservative, and there will probably be breakdowns due to an imperfectly

trained staff. Such difficulties accompany most new ventures but should not prove insuperable. There is every reason to believe that steam threshing is now a practical proposition and that it will enable the present vicious circle depending on the excessive demand on agricultural cattle to be broken.

AGRICULTURAL PROGRESS IN TRAVANCORE.

BY

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The following is a short account of the work that has been done towards the development of agriculture in Travancore.

In 1908 a Department of Agriculture was organized with a Director at its head. On the recommendation of the Director the Demonstration Farm which then existed at Trivandrum was co nverted into an Experimental Station, the superintendent being designated Agricultural Inspector, and his two assistants Agricultural Sub-Inspectors. A new Experimental Station was opened at Kottarakaray, in Central Travancore, and a cattle-breeding farm at Trivandrum ; two Agricutural Inspectors and a Laboratory Assistant were newly entertained, and about 2 years later a cocoanut farm was opened at Alleppey in North Travancore. The Laboratory Assistant and one of the Agricultural Inspectors are undergoing training, in agricultural chemistry and entomology respectively, in the Agricultural Research Institute at Pusa, and the laboratory is for the time being in the charge of a temporary substitute.

The Department of Agriculture in Travancore works almost on the same lines as other Agricultural Departments in India. The work includes field experiments, the analysis of soils and manures, demonstrations on cultivators' lands and on the experimental and demonstration farms, and the distribution of small quantities of seeds and manures free of charge ; besides lectures,

exhibitions, and the publication of leaflets and reports. A quarterly Agricultural Journal is also being started.

The most noteworthy result of the work of the Agricultural Department is the general interest it has been able to stimulate among the people in scientific agriculture. Even the ryots of out of the way places have opened their eyes and begun to see the immense possibilities that are open to them for improving their agricultural methods. The ever increasing number of enquiries from the ryots of different parts of the State bears ample testimony to the interest they evince in matters agricultural. This is a healthy sign of agricultural progress in the State.

The attempts of the Department for the introduction of light iron ploughs are being attended with a considerable amount of success. The Department usually stocks a number of these ploughs and disposes of them according to demand. In the year 1910-11, 20 ploughs were sold in this manner, but in the following year the number sold rose to 107, and in the current year a still larger number has been sold.

In the matter of manures the most noticeable features are the recognition by the ryots of the necessity of manuring their crops systematically; the appreciation of the value of locally available manures, such as oil-cakes, fish, etc.; and the care and attention bestowed on the preservation and use of the all-important cattle manure.

Many ryots who have hitherto been careless in the matter of manuring their lands are now willingly purchasing manures for substantial amounts. Laurel poonac (oil-cake from the seed of *Calophyllum inophyllum*), which is available in large quantities in South Travancore and which has till recently been entirely going out of the State to enrich the lands in other countries, is now very largely used by the local ryots themselves. More than that, the ryots of South Travancore have also begun to use bone-meal, saltpetre, nitrolim, and similar artificial manures, for their rice crop.

In Central Travancore, which is noted for cocoanut cultivation, the Department has opened a few manure depôts for the sale of

manures for the cocoanut palm. In the year 1910-11 manures were sold from these depôts for nearly Rs. 7,000 and in the following year for about Rs. 12,500.

The ryots of Travancore have had erroneous notions about the uses of lime in the soil, but are now gradually changing them, and, as a consequence, liming is becoming a regular practice in some parts of the State.

Single seedling transplantation of paddy is also steadily gaining ground in the State. This method was first demonstrated in South Travancore in 1910-11. In the following year more than 150 acres, and during the current year nearly 500 acres, were brought under this system in that part of the State, while it has extended on a limited scale to other parts as well.

New varieties of rice and sugarcane, and exotic crops such as groundnut, maize, etc., have been introduced into the State and are becoming popular. Banku paddy, which originally came from the Central Provinces, is found to be a better yielder than many of the local varieties of paddy, and is hence very much appreciated by the ryots. Among exotic crops one that is specially suited for Travancore is groundnut, and its cultivation is steadily extending in the State. The increased importance that is now attached to the improvement and extension of sugarcane cultivation all over India has stirred up the ryots of Travancore also. Many of them are discarding the varieties of canes they have been cultivating from time immemorial and are readily going in for new and improved varieties distributed by the Department, while others are opening up fresh lands for the cultivation of this crop.

The cocoanut palm, on which the prosperity of Travancore may be said chiefly to depend, is having its due share of attention. At the instance of the Agricultural Department certain improvements are being effected in the cultivation of this palm, especially in the methods of planting and manuring.

The above are some of the salient features of the progress made till now in the introduction of agricultural improvements in Travancore. The field for work is a very wide one and only a small portion of it has been touched so far. With the advance

of general education which is fast spreading in the country and with the strengthening of the Agricultural Department in its staff and resources which is bound to take place in course of time, the difficulties that now impede agricultural progress in the State ought to disappear and the labours of the Department ought to be crowned with far greater success than at present.

GREEN MANURING AND HOT WEATHER CULTIVATION IN THE PUNJAB.

By

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As some very misleading statements have recently been given currency regarding wheat growing in the Canal Colonies of the Punjab, it has been thought necessary to point out some of the more patent economic factors obtaining in these colonies, in their bearing on the two very important methods of soil improvement known as "green manuring" and "hot weather cultivation."

As regards green manuring, this practice is already in vogue in certain districts, *e.g.*, Jullunder and Ludhiana where *sann* (Crotalaria juncea) and *guvara* (Cyamopsis psoraloides) and *senji* (Melilotus parviflora) are the green manuring crops most commonly used. Of these crops, *senji*, in Lyallpur, often requires as many as six waterings. The crop is a very useful fodder, and an acre would be worth Rs. 40 in February and March when it is generally cut. Ploughing in, therefore, would be wasteful. *Guvara* and *sann hemp* are both *kharif* crops; sown generally in early July. *Guvara*, although less bulky than *sann*, yet is said to decay much slower, and is therefore not so useful as *sann hemp* for the Colonies, especially as, generally, a *rabi* or winter crop has to follow the green manure crop within two months after ploughing in the latter. Most probably, therefore, *sann hemp* is the green manure crop best adapted for the Punjab Colonies.

Now, in the Chenab Colony, irrigation is only promised for $66\frac{2}{3}$ per cent. of the land, *i.e.*, sufficient for the cultivator to crop $\frac{2}{3}$rd of his area annually. Of this area cropped, $\frac{2}{3}$rd is taken in the winter season. As a matter of fact, cultivators as a rule manage to crop their land 110 to 125 per cent. annually, and some do much more than this. (Cultivators are charged for water according to cropped area, and not according to quantity of water used, but slightly different rates exist for different crops). Consider the case of a cultivator wishing to green-manure two classes of land, *viz.* :—(*a*) poor light sandy soil, and (*b*) a fair medium loam.

The cost of green manuring may be approximately estimated as follows :—

	Rs.	As.	P.
(1) Cost of seed (Rs. 4-8 to Rs. 5-0 a maund, at Lyallpur) ...	4	0	0
(2) Sowing and previous cultivation (2 ploughings and a *sohaga*—or harrowing)	3	0	0
(3) Waterings (applying same)	1	4	0
(4) Water-rate (not charged by Canal authorities since 1910-11) ...	......		
(5) Ploughing in of crop	2	0	0
TOTAL Rs. ...	10	4	0

It is advisable to use an inverting plough to get the crop properly covered—in the above estimate it is supposed the native plough would be used. The total cost, Rs. 10-4 calculated in this way, is similar for the two classes of soil (*a*) and (*b*). A truer estimate of the cost can however be got if we consider the value of a fodder crop like, say, a mixture of *guvara* and *jowar* (Andropogon sorghum) grown on the two classes of land. This mixture is commonly grown by cultivators, and as it contains a leguminous crop it cannot be regarded as very exhausting to the soil. In light poor soil the value of such a crop would be Rs. 15 to Rs. 20, whereas in a loamy soil it would be worth Rs. 30 to Rs. 35 per acre. The expenses of cultivation would be very similar to those for *sann hemp.* The above mixture can often be sold on the land so that the expenses of cutting are saved. There is never enough water to crop the land as often as the

cultivator would wish and he naturally regards the cost of green manuring according to the value of the crop it might have replaced, *i.e.*, Rs. 10 or so for poor land, and Rs. 20 to Rs. 25 for fairly good average land. The better the land the higher, therefore, is the cost of green-manuring it. Again, the green-manured crop is generally ploughed-in in early September, and as it requires about 4 or 5 weeks at least to decay very little time remains for cultivating the land for wheat, which is sown before the 10th of November. This decay seems to take longer in the heavier soils than in the light sandy soils, and this seems to indicate another reason for confining the practice to the latter class of soil. The increase in yield also, as far as can be judged from the past two seasons, is greater in light soils. In one case at Lyallpur, with barley, the crop in an area of 3 acres increased from 11½ mds. in 1909 to 42 mds. in 1910-11, after green-manuring in the rains of 1910 (see Annual Report of the Department of Agriculture, Punjab, 1910-11). The above is a remarkable case, as the land had become nearly useless previous to treatment. As a rule the increase in yield is from 3 to 6 mds. per acre, in the first year, in light soils.

From the above it is fairly obvious that the practice of green-manuring for enhancing the yield of good land is very expensive, and at present only of academic interest for the canal colonies.

Hot Weather Ploughing.

In the Chenab Colony, from a ½ to ⅔rd of the area cropped by a cultivator is generally under wheat or barley. Wheat is generally grown on the heavier land if possible. The area of grain being so large it must necessarily follow that wheat often follows wheat in the rotation. The following are the crops which may precede wheat, *viz.*, cotton, *toria* (Brassica campestris)—to a small extent only gram, fodder crops, such as maize, *gurara*, *jowar*, and sugarcane. Now in case wheat follows cotton, *toria* or sugarcane, these crops being off the land by the end of January, it is the universal custom to plough the land up as soon as rain comes, which is generally the case in January, February

or March. The land is thus exposed during the hot months of April, May and June. When, however, the previous crop is wheat, gram or barley, which are harvested in latter part of April and early May, the conditions are very different. At this period the heat is intense (95° to 110°F. in May), and the air very dry. The wheat land at harvest time is dry and very hard, and it is practically impossible to touch it with ordinary cultural implements. Besides, labour is very dear and the cattle are busy threshing the wheat, in case rain should come and cause damage by discolouring the wheat or causing it to germinate. Rates for daily labour at harvest time run from As. 12 up to Re. 1-4 and 1-8 a day. Should rain come, as occasionally happens in May, the cultivators cannot proceed with the harvesting operations, and they do what they can in breaking up land. In ordinary years, however, it would be necessary to water the land in order to be able to plough it at this time of the year; water could ill be spared for this purpose, as the young sugarcane and the cotton require all that is available. The labour question appears, however, to be the greatest difficulty, and it is in this direction that the Agricultural Department is attempting to improve matters, by the introduction of labour-saving appliances in cutting, winnowing, and threshing. Any saving of time by improvements in this direction could be very profitably utilised by the cultivator in intercultivating his cotton and sugarcane, and also, if possible, in tackling his wheat fields.

BERGSON AND BOTANY.

By

ULULA.

Most of us are to some extent familiar with the work of Prof. Bergson, the most brilliantly persuasive philosopher of our times. It represents in some aspects a reaction against the idea of a machine-made universe. He puts science and the human intellect in their proper place below the salt, and in a much-quoted passage compares our view of phenomena to that of a person who inspects one by one the pictures on a cinematograph-film, unable to see the moving whole projected on the screen. He considers that tools and machines have to some extent made man, mentally, what he is, and sees no reason for considering the mentality of an ant to be on a lower plane than our own; it is merely on a different one; the plane, that is, of instinct or intuition as opposed to mechanical reason. There is then more than one kind of intellect, and if our aim is to realise the living universe we must not confine ourselves to the partial view accorded to mere reason.

Bergson believes that it is possible for us to cast off at times the shackles of logical thought, and recommends that, as a mental exercise, the effort should be made, although he admits that the line of instinct is unlikely to guide us to any practical or even tangible results beyond an enhanced consciousness of the living flow and interplay of things. It is of course unfair to charge him, as has occasionally been done, with suggesting that scientific investigators can or might profitably adopt the standpoint of an ant instead of the ordinary methods of logic.

On lines determined thousands of generations ago, our human intellects are now moulded for better or worse, tools efficient for progress along those avenues whereby our race has from time immemorial approached the study of matter. Our consciousness of the living flow of things is personal and incommunicable; though it is not capable of being employed to obtain concrete results, it gives a mental light and atmosphere to our meditations.

These remarks may seem to have little bearing on what follows, but we seem to detect the Bergsonian influence, perhaps too large a reliance on the ant-like view, in the opinions expressed or implied in an article which was published in the April number of this Journal as a review of Mr. W. Lawrence Balls' book "The Cotton Plant in Egypt—*Studies in Physiology and Genetics*." We have not read the book, but may quote the reviewer's description. "Possibly no reader of the book, certainly not the layman, will question its thoroughly 'scientific' character. It is a mass of figures, diagrams and curves in which are presented quantitatively in what is, from the mathematical point of view, the most concise and intelligible form, the variations in the environment of the cotton plant in Egypt and in its physiological functions: the correlation between the two being worked out in a large number of cases after the methods popularised by Galton and Karl Pearson. And, without the technical knowledge to enable him to form an estimate of the skill and judgment with which these methods have been used, the reader is free to admire the ingenuity and industry displayed by the author in their application."

"Who," observes the reviewer, "that has gardened in a hot climate, does not know, by the intuition derived from many little unrecorded observations, the stunting effect of the afternoon sun in dry weather, shown in extreme cases by the flagging of leaves and remedied by judicious pruning or shading; or again the unhealthy appearance of plants that are suffering from water-logging either owing to bad drainage or heavy and prolonged rain; and why—why is it necessary to measure and record, as the author has done, the exact value of the factors concerned in any particular case?"

Mr. Balls' *Studies in Physiology and Genetics* were of course not written for the immediate use of amateur gardeners; even a really good *mali* would probably suck but small advantage from their perusal. They appear to represent the foundation for an intensive study of the cotton-plant and its environmental reactions. The reviewer is of the opinion that this is not a fit subject for an economic botanist to pursue. He considers that in such matters he should be content with the *mali's* empirical and half-intuitive knowledge, "the integration of many little unrecorded observations:" that he should at any rate leave the attempt to do original work to those who have leisure, contenting himself with the practically mechanical application of the results handed out to him in peptonized form by the leisured investigator, and that his work should largely or entirely consist of the selection and isolation of types suited to the various local conditions of the country in which he works. That he should be in point of fact a nursery-gardener employed by a Government instead of by a commercial firm; paid to get results, not to try to discover the "reason why."

Save perhaps "for those few Economic Botanists who are more botanical than economic" (and who are doubtless well able to fight their own battles), no one will deny that such a view of their functions is a very sane and reasonable one under the circumstances. The "pure," and purely quantitative, research work of the Abbé Gregor Mendel has given them enough to occupy them profitably for at least a generation, in isolating and combining plant characters to fit man's commercial requirements. Mendel, the leisured investigator, has opened the door. The obvious thing to do is to walk in and appropriate the swag.

So far so good, but the reviewer does not stop here. He says: "But if we assume that these investigations are not blind alleys, that the author had in view some scientific object for the ultimate attainment of which these—may one say—*sordid* quantitative investigations are essential; the fact remains that the large amount of work here recorded does not appear to be

of any immediate economic importance. Moreover, it may be suggested that even from the scientific point of view, the expenditure of time by an official of an Agricultural Department on such work is a mistake. We know that the rendering to Cæsar of the things which are Cæsar's is not incompatible with the highest of ideals. It is questionable whether the field of so called "pure" science should not be left to those whose circumstances permit them a perfectly free selection of phenomena to investigate."

Now here he opens up, designedly or otherwise, a question of wider interest. The quotation referring to Cæsar is perhaps a trifle unfortunate, since this reputed saying of Christ has given rise to bitter theological controversy as to whether it may not be a gloss due to official influence, but apart from that it is surely meaningless in the present connection until we know what *are* "the things that are Cæsar's." In other words, why does a Government, why for instance, does the Government of India, maintain any officers in its Agricultural Department beyond those engaged in purely executive work or in the comparatively straightforward application of known rules? In those branches of biological investigation in which no Mendel has yet smoothed the path, in Bio-chemistry, Bacteriology, Entomology, Mycology, what, to put it bluntly, does Cæsar expect? And what is he likely to get? This is in no way an idle question, even if we consider merely its bearing on the policy governing departmental publications.

It should be clearly realised that the leisured investigator in Europe has up to now rendered only comparatively meagre contributions to the practical needs of workers in foreign lands, and that even those contributions are, more often than not, quite unnegotiable in the peculiar social, physical, and financial conditions of India. India must, in biological investigation, to a great extent work out her own salvation with the resources available on the spot. That we should attempt to cut adrift altogether from Europe and America to form an isolated scientific microcosm, is of course unthinkable and impossible. On the contrary, the natural tendency already evident is towards a

progressively closer connection in other matters besides the purely descriptive and classificatory.

To say that workers at home in, for instance, Entomology, would do better to direct their attention, as they are beginning to do, to such subjects as insect-physiology rather than to discussions about nomenclatorial priority, and that workers in the biological sciences abroad should have the economic aspect always in view, is a fundamentally different position from that which our reviewer takes up when he says "the large amount of work here recorded does not appear to be of any immediate economic importance. Moreover, it may be suggested that even from the scientific point of view, the expenditure of time by an official of an Agricultural Department on such work is a mistake." This can only mean that in the publications of our own Department, for instance, no work which is not of direct economic importance should appear, and no officer of the Department should take up any piece of work unless he can, practically speaking, guarantee that it will lead to some commercially profitable result.

From the point of view of the businessman this is a perfectly sound and sensible position. It is in fact practically identical with that generally adopted by planting communities who employ paid scientific advisers. In actual practice it hardly produces the results one might expect.

A consideration of the relative development of the different sciences which are studied partly for their bearing on Agriculture will throw light on the reasons why such a policy is unsatisfactory. The "direct economic importance" of cattle and plant-breeding has been recognised for many centuries, and now Mendel has indicated to the breeder a royal road to profit: similarly, the extraordinary development of some branches of industrial chemistry in Europe during the last fifty years, largely due to the encouragement of pure research, has resulted in numberless new processes of commercial value, by-products of the general activity. In these cases the sciences, or branches of science, have passed through their period of economic infancy. Firmly rooted on a broad basis of accurately-ascertained fact, of "*sordid*

quantitative investigations," they are now expanding in a vigorous and confident growth. From the breeder and the chemist we may ask for immediate practical results, and within certain limits (the limits to which the pure researcher has gone) we may expect to get them.

In Bacteriology (save in a minor degree in connection with human disease), in Entomology, and in Mycology there is as yet no such broad basis. These sciences are themselves too new, and in particular the increasing recognition of the extent of their economic importance is of too recent a growth, to permit them to compete on equal terms with such well-established industries, if we may so term them, as analytical chemistry or nursery-gardening. The cheap and efficient control of bacteria, insects, and fungi will come, but only as a consequence of a very much deeper understanding than that which we now possess of their physiological mechanism and of the factors which influence their activities.

Who is to gain that deeper understanding? The reviewer's answer is "those whose circumstances permit them a perfectly free selection of phenomena to investigate." Let us suppose, then, that the Research Department of the Imperial Institute undertakes the elucidation of the unknown factors determining the degree of prevalence of the parasites of Lepidoptera or the effect of a changing electro-magnetic field on the increase or decrease of the toxicity of certain bacteria or root-fungi, or indeed any bit of pure research which might allow us to get at the inside of things instead of indulging in a futile promenade on the surface. Then any necessity for such research in India itself will naturally disappear, and it will be difficult to justify the retention of any officers save those whose duties are purely executive, mechanical, or educational. If it were decided on general grounds that the services of such officers might be retained, but that they should not engage in or publish any work which was not of direct and immediate economic importance, there would seem to be three courses open to them: (1) To research in secret. (2) To do nothing. (3) To do nothing in particular, but to do it very well.

The third course is the one which would probably commend itself. To collect a little of the economic cream which floats on the surface of a subject, to serve it up at sufficiently frequent intervals, dissolved in eye-wash and suitably flavoured, is a process whose value has often been demonstrated. In cases where the subject is so undeveloped that the cream has not yet had time to rise, one can fall back on eye-wash pure and simple, or perhaps manufacture a "cream-substitute" out of Bergsonian intuitions, with a few unverified suppositions and conclusions to impart body to the mixture. But of what ultimate profit is all this, save as a method of advertising? It can hardly be recommended as the policy of a Department in the matter of research.

It seems to us that only a very imperfect appreciation of the real state of biological knowledge as applied to India could suggest the suppression of all not strictly economic work, which is the suggestion made by the reviewer; that unless our energies are to be devoted mainly to advertisement, "pure" research must be recognised in India, as it has been recognised in Europe, America, and Japan, as a *necessary condition* for real progress, not as a luxury or a mere concession to opinion. Two-dimensional science may have its uses apart from advertisement, but if we are never to go below the surface how much "forrarder" are we likely to get in the long run Although we are accustomed to distinguish between "pure" and "applied" science, there is of course no hard-and-fast line between them. The word "pure" in this connection is used for work designed to give us a knowledge of facts, principles, and relations, which may afterwards be applied to problems of economic interest which cannot satisfactorily be solved by intuition or by the exercise of ordinary common-sense.*

To engage in an original enquiry, which may or may not give immediately applicable results, taking as one's subject some animal or plant of known economic importance, is obviously

* The reviewer seems to have wished to combine this idea with that of moral purity, but there seems no need to attach fresh meaning to a well-understood phrase.

the merest subterfuge. It is simply to research in secret, using some well-known name, such as "Wheat-Rust," "Boll-Worm," "Paddy," as a talisman to guard against interference. We are asked to accept the opinion that the records of these clandestine operations should always be carefully screened from the myopic eye of the public, and that our constant aim should be to "keep the patient amused" even though it may only be by blowing bubbles. Surely it would be far better at once to let him know the worst, that, in those branches of science which are still in their economic infancy, India must take her share in supplying the nourishment necessary for growth, unless she thinks that cream-substitutes will meet the case.

The following quotation from the report of a recent speech by Mr. Balfour indicates very clearly the views of one who is justly renowned as a philosophic thinker.

"Lord Rayleigh had expressed a faint regret that in the history of this institution a larger fraction of the labour had been devoted to matters immediately connected with industry than to the abstract or purely scientific investigations on the successes of which, ultimately and as years went on, the future of industry depended. They must all share that regret. It was one of his foremost articles of social faith that it was to the labours of the man of science, working for purely scientific ends and without any thought of the application of his doctrines to the practical needs of mankind, that mankind would be most indebted as time went on. Holding that faith, he desired that as much advance should be made in pure science in those buildings as money and space allowed. The general public did not realize that it was to the results of pure science that they had owed in the past and would owe more and more in the future all great advances in industrial knowledge and practice. *Still less did they realize that the man of science who was working consciously towards that end was only half a man of science, and was not likely to do his scientific work nearly as well as if he were simply and solely occupied in advancing that branch of knowledge with which he was connected. He hoped these truths would slowly and effectually sink into the*

public mind as time went on. If that happened, many of them would see the time come when those responsible for the finances of the country would not feel it necessary to say "What immediate practical results to the taxpayer are you going to get from the sacrifice which you are asking the taxpayer to make?"

If indeed our existence depends so largely upon advertisement that we really cannot dispense with it, let our aim in advertising be to educate, the public on the lines indicated by Mr. Balfour; to combine, as it were, instruction with amusement.

We have written at what is perhaps an intolerable length. Our excuse is that the Agricultural Department as a whole seems to have reached a stage of development where the superficial nature of our knowledge of many fundamental matters is beginning to intrude itself upon our notice. It seems that in response to a demand for immediate "work-a-day" results, we have been tempted into a wide expansion of activities upon an insufficient basis of accurate knowledge, and that the need for concentration upon comparatively restricted lines is becoming increasingly obvious. Under these circumstances such opinions as those expressed in the review under notice, as to the initiation and publication of pure research, if applied to biological enquiry as a whole, are to be regarded as reactionary rather than progressive. The degree of recognition to be accorded to biological research is not a matter to be lightly dismissed, for upon it depends the whole future complexion and status of the Department. Careful observation, organised enquiry and research, the application of its results to practice, the testing, demonstration and advertisement of improvements, and, when a sufficient body of accurate knowledge has been accumulated, the education of others; these may be said roughly to sum up the activities of the Department, a Department which has to do with the welfare of over three hundred million people. Condemn it to a parasitic existence on the brains of experts at home, and the result will be an emasculated fraud. Give every possible encouragement to research on reasonable lines, and in twenty years we shall be a power in the land, a strong and solid growth rooted in Indian soil.

FURTHER WORK AGAINST SURFACE CATERPILLARS AT MOKAMEH IN 1912.

By

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In a previous number of this Journal* an account was given of the success which had attended the use of the method of handpicking the early broods of caterpillars to prevent the destruction of the crops on the Mokameh *tal* by surface caterpillars (*Agrotis ypsilon*). Reference was also made to a trial of the Andres Maire trap for Noctuid moths, and it was hoped that it would be possible to use these traps on a large scale for combating the pest. The present paper records the results of this experiment.

Before giving a detailed account of the present year's campaign, it will be necessary to give a summary of the conditions prevailing on the Mokameh *tal* for the benefit of those who have not read the previous paper. The Mokameh *tal* is a large shallow basin of very stiff clay soil, which is inundated during the

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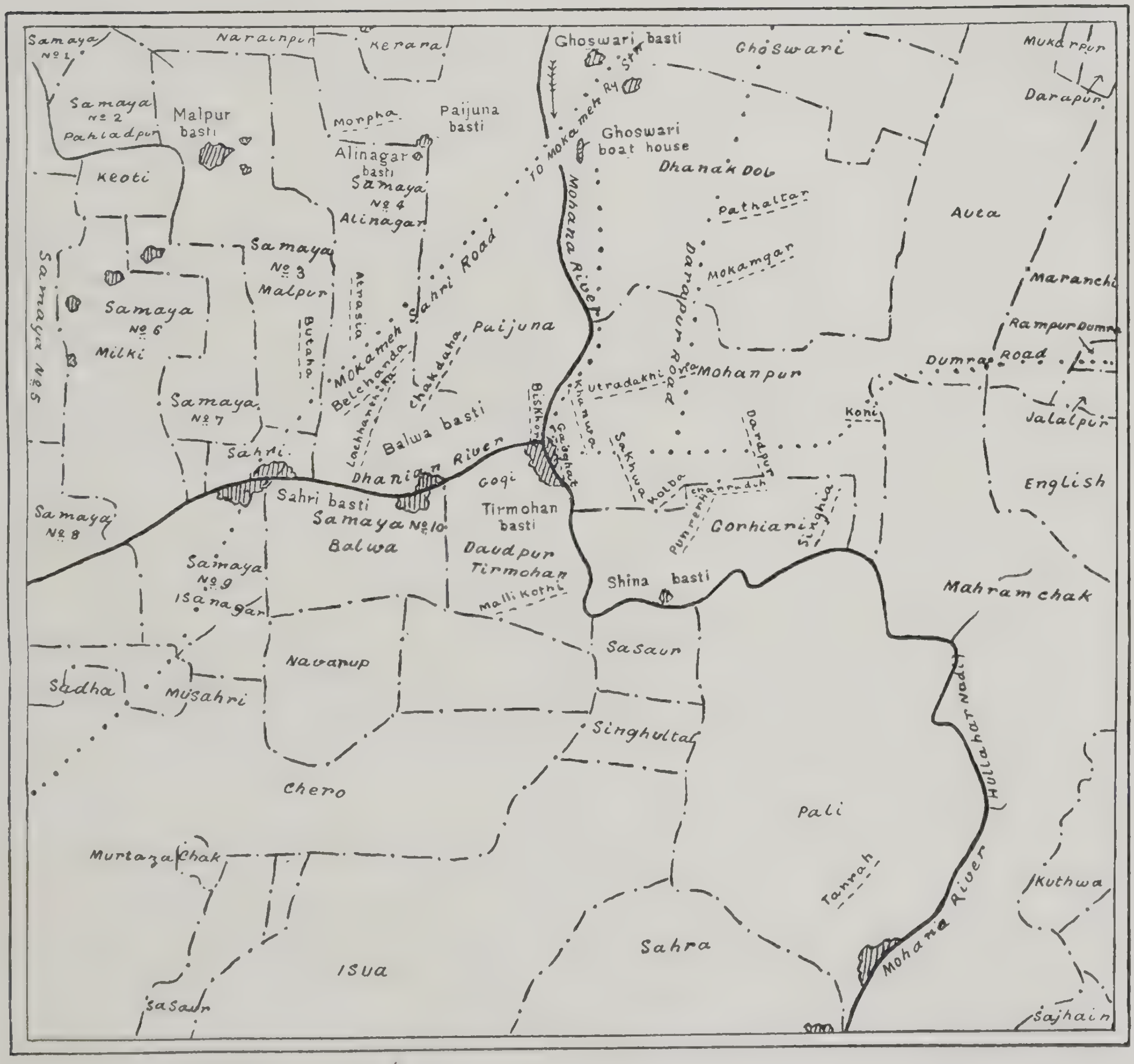
* Vol. VII, Part IV, Oct. 1912. The Caterpillar Pest of the Mokameh *tal*, by E. J. Woodhouse and T. Bainbrigge Fletcher. This summarises the information contained in the two following papers :—

Bengal Quarterly Journal, Vol. IV, No. 4. The Insect Pest of the Mokameh *tal* lands by E. J. Woodhouse and H. L. Dutt.

Bihar Agricultural Journal, Vol. I, No. 1. Surface Caterpillar on *tal* lands by E. J. Woodhouse and H. L. Dutt.

Mokameh Tal; Showing the Village Sites, Mauzas, and Kitas.



Scale 1 inch = 2 Miles

References

Mauza Boundary . . . .

Road . . . .

River . . . .

rains by flood water from the Gaya hills and by the backing up of the water of the Ganges during high floods in that river. The flood water drains slowly out of the basin through the Mohana river as the Ganges falls in September or October. There is usually an interval of about one month between the drying of the highest and lowest areas; the land is usually ready for cultivation some ten days after the flood has receded. The only crops grown on the *tal* are *rabi* crops such as *Masur* (Lentils), *Khesari* (Lathyrus sativus), and peas which are chiefly confined to the higher areas. As soon as the land is sufficiently dry these crops are sown by means of a *tanr* (a combined plough and drill) without any preliminary cultivation. This implement breaks the land up into large blocks which cover up the seed lying in the moist furrow. The land receives no further treatment until harvest but the blocks slowly break down.

Attention must also be drawn to the habits of the insect (*Agrotis ypsilon*) in as far as they affect the question. The pest is active during the cold weather in the Gangetic plain, and as nothing is known of its whereabouts during the hot weather, it has been assumed that it æstivates in the Himalayas. The moth is a strong flying insect which is not usually attracted by light, but lives for some time as an adult, during which time it feeds and lays eggs. It appears to be especially attracted by newly ploughed or irrigated soil on which it lays its eggs. The caterpillar lies hidden in cracks in the soil by day and feeds at night by cutting off the stems of young plants. The extent of the damage caused by the caterpillar depends on the fact that it does not content itself with making a meal off the first plants cut down by it, but moves about freely and may cut off a large number of plants in one night. In spring the life history of the insect takes about six weeks, but there is evidence to show that this is reduced to a month in autumn.

In the *rabi* season of 1909 the Patna Divisional Agricultural Association drew the attention of the Department to the fact that the crops on the lower areas of the *tal* had been destroyed annually by caterpillars during the previous fifteen

years. This information was received too late to enable anything to be done that season, but an inspection of the *tal* showed that the crop had been destroyed over an enormous area in that year.

In 1910 various experiments were tried, and a careful study was made of the conditions prevailing on the *tal*. As a result it was decided that the most promising line of work for the following year was to pick off the caterpillars of the early brood which had been found to appear in the previous year on the higher and earlier sown areas: by this means it was hoped that it would be possible to prevent the production of the destructive brood which had appeared in the lower and later sown areas, six weeks later. This policy was followed, and proved extremely successful, in that it reduced the damaged area from ten thousand to less than three thousand five hundred acres.

At the same time a trial was made of the Andres Maire trap imported from Egypt. There were great possibilities before this trap for the work at Mokameh because it was likely to enable us to attack the pest at an earlier stage than had hitherto been possible. It was hoped that it would be possible to use the traps for the purposes of destroying the moths as they flew on to the *tal* and before they would have had time to lay their eggs. In principle the trap is an application of the well-known method of capturing moths by sugaring, with the addition of a cage which permits the moths to enter but prevents them from escaping (Plate XXXVI). The traps are raised some four feet off the ground in order to increase the distance to which the scent of the attractive liquid is carried. The four sides of the trap each consist of six sloping platforms of wire gauze, the underside of which is horizontal. The moths walk up the projecting platform and enter the trap by a narrow slit between it and the horizontal portion of the platform above. In the morning the moths retire to the darker portions of the trap, and many of them are drowned in a reservoir of water covered with a film of kerosine oil. A pulley is fitted inside the top of the trap, over which passes the rope for raising and lowering the gunny bands on which the attractive liquid is spread. When the trap is in

PLATE XXXVI.

ANDRES-MAIRE TRAPS.

use the bands are charged with the attractive liquid ("Prodenine") and raised at sunset; the traps are again visited the next morning and the bands are lowered and packed away in a box at the base of the trap, after the catch has been removed. In November 1911 nearly three thousand Agrotis moths were caught in one trap.

For the 1912 campaign it was decided to make use of some twenty traps, which were to be stored in the villages of the *tal*, in May, and brought into use as soon as any catches of Agrotis were reported from the observation trap to be worked throughout the rains at Paijuna. The traps were to be organized in batches of about six, each batch being placed under the charge of a trap operator, stationed at Paijuna, Tirmohon, Sahri, and Pali, with head-quarters at Ghoswari. It was not expected that the moths would appear until after the middle of August, and it will be seen that this forecast was correct. As soon as any catches of Agrotis were recorded in the observation trap, the traps were to be taken out of storage and worked on the high lands surrounding the lower areas usually attacked. The traps were to be moved outwards on to the lower lands as the water receded from them.

Great stress was laid on the importance of getting the traps on to the low lands while these were still wet, as our observations in the previous year had led us to believe that the moths lay their eggs on these lands while they are still muddy. At the same time a careful watch was to be kept for broods of caterpillars on the high lands, and any caterpillars found were to be destroyed.

By the time the floods would have finally receded all the traps would be in their final positions on the low lands where the bulk of the damage is usually done, and the work of the staff would consist in supervising the regular working of the traps and in searching continuously for the first appearance of the caterpillars which were to be picked off forthwith.

In accordance with this scheme arrangements were made for constructing the necessary traps, which were stored on the

tal by the end of June. An observation trap was worked throughout the year at Paijuna, but in April only thirty two moths were caught, and from April 28th until August 18th no catches of Agrotis were recorded. On August 27th work was started at Ghoswari, and by September 10th seven traps were working round Ghoswari, Paijuna and Tirmohon, but the commencement of the work at the more distant stations of Sahri and Pali was delayed by the difficulty of procuring accommodation for the trap operators. On September 21st twenty traps were working over the *tal* and the work rapidly settled into shape with the final re-arrangements of the Tirmohon, Sahri, and Pali traps on the low lands on September 22nd, September 24th and October 1st, respectively. That the traps were doing efficient work can be seen from Appendix I. The working of the traps was continued until January 6th, when only two or three moths were being caught nightly in each trap. A daily statement of the catches is given in Appendix I, and the position of the traps is shown in the map opposite. As many as one thousand and three Agrotis moths were caught on one night in one trap.

On September 22nd the first Agrotis caterpillar was found on uncultivated land near Khanwa, but it was not until October 9th that the first attack was reported, from Utra Dakhina (near Sakhoa), and from this time onwards until the end of the month eleven attacks were located and 107,439 caterpillars handpicked and destroyed. The details of these attacks will be found in Appendix II, from which it will be seen that the attacks (with one exception) occurred in close proximity to the traps (see also the map). No damage was done by the pest after October.

In the two previous seasons the agricultural conditions had been abnormal in that the flood water remained on the *tal* for a month later than usual and ploughing could not be commenced until the end of October. The present season, on the other hand, was an abnormally early one. There was no proper flood until the end of August, when a slight flood occurred but began to recede on September 4th. By September 22nd the *tal* was drying very quickly and there was very little flood water left. A

Mokameh Tal; Showing the Position of the Traps and Attacked Areas in 1912.

D_A, D_B &c . . . . First positions of Traps.

T_A, T_B &c . . . . Final positions of Traps.

(1) (2) &c . . . . Position of attacked area numbered according to Appx. 3.

Pj . . . . Indicates that those Traps were under the paijuna Trap operator

S. . . . . „ „ „ „ Sahri „ „

D. . . . . „ „ „ „ Dhanak Dob „ „

T. . . . . „ „ „ „ Tirmohan „ „

P. . . . . „ „ „ „ Pali „ „

little cultivation was then in progress in the higher lands, but it was not until September 28th that the sowing of the Mokameh *tal* was commenced in earnest. At this time the *tal* had become so dry that only scattered areas of such high or low lands as had sufficient moisture were being sown. A shower on October 5th enabled a little more land to be sown. It was fortunate, therefore, that heavy rain fell on November 2nd, which increased the germination on the plots already sown and enabled the uncultivated plots to be sown. A second heavy fall of rain occurred on November 24th, 25th, which made it certain that a full crop would be obtained if no damage was done to it by insects or other pests.

The crop over the whole area was practically a full crop, and the actual areas damaged by Agrotis did not exceed 100 acres, though in some places the crop had been damaged by crickets or had germinated badly. The crop over the whole *tal* may be estimated to have yielded 16 mds. per acre, valued at Rs. 2 per md. On this basis* the money value of the outturn of the ten thousand acres of crop normally destroyed by Agrotis works out at 3·2 lakhs of rupees (about £21,000).

With the above information before us we are now in a position to discuss the efficiency of the Andres Maire traps.

That there is no doubt that the normal amount of crop would have been destroyed if no steps had been taken to prevent such an occurrence is proved by the figures showing the number of moths and caterpillars caught. A simple calculation will perhaps make this point still clearer. In 1911 it was found that seven caterpillars per square yard were found on badly attacked areas, so that we may assume that thirty-five thousand caterpillars should be sufficient to destroy one acre of crop and that three hundred and fifty million will be required to destroy ten thousand acres. A reference to Appendix III will show that eight thousand female moths were captured in September, which would each

* Owing to the fact that a bigha is slightly larger than $\frac{2}{3}$rd acre, the value of the crop if calculated in bighas works out at 3·6 lakhs (£24,000).

have produced some three hundred eggs, half of which would turn into female moths and give rise to some three hundred and sixty million caterpillars by the end of November. To these must be added some nine millions of caterpillars derived from the moths caught in October and another sixteen millions which would have been produced by the caterpillars picked during that month. It is therefore clear that the insects destroyed, up to the end of October, were amply sufficient to produce the normal amount of damage at the end of November when the attack usually occurs.

In view of these figures the explanations offered by the cultivators of the Mokameh *tal* to account for the decrease in the damage done by Agrotis during the last two years are not very convincing. The decrease is most frequently ascribed to heavy showers of rain in November, which are supposed to destroy the caterpillars, but this hypothesis is disproved by a comparison of the rainfall of 1910 and 1911, during both of which years heavy rain fell in the middle of November. In 1910 about the normal amount of damage resulted, but in 1911 the handpicking of the early broods of caterpillars reduced the damage by some 6,000 acres. The absence of the pest on the Pali *tal* has been said to be due to the increase of *Kharhar* grass, but no such increase has been observed by us. Our own study of the local conditions has led us to consider that the conditions during the present year were if anything rather more favourable to the pest than usual, but it is unnecessary to discuss the question in detail here. Sufficient has been said to show that the only satisfactory explanation of the diminution in the numbers of caterpillars on the *tal* is afforded by the work done by the traps.

The Andres Maire traps do not, however, appear to have proved a success in Egypt, and Dr. L. N. Gough, Entomologist to the Egyptian Government, states that the traps have been rejected in Egypt for use against Prodenia because the percentage of females caught in the traps is low and almost all those caught have been found to have already laid their eggs.

The traps are also said to attract moths from a distance, and the females do not always enter the traps, but lay their eggs near them. The traps are said to work better with Agrotis than Prodenia, as in the case of Agrotis the proportion of gravid females caught is higher.

In Appendix III will be found a statement showing the proportion of females to males caught in the traps during the season's work, from which it will be seen that the percentage of females varied from 56·5% during September to 33·07% in November. There was some difficulty regarding the diagnosis at first and the earlier figures are probably not very accurate, but after November 7th the hairiness of the antennæ (bipectinate) in the male as compared with the absence of hair (filiform) in the female was taken as the critical character.

A series of observations was made on the amount of eggs remaining in the female moths caught in the traps and it was found that the female moths usually contain a considerable number of eggs. That the catches recorded at Mokameh have been satisfactory both in regard to the percentage of females and their egg content is confirmed by the absence of caterpillars over the *tal*.

There is no doubt that a small proportion of moths do escape from the traps. This can only be prevented by taking particular care to see that the openings by which the moths enter the trap do not exceed one-third of an inch, and that the wire screens are not allowed to press against the bars of the frame, so that the moths may not crawl up the inside of the trap to reach the openings. A study of the map opposite page 376 and of Appendix II will show that during the past season only one attack occurred at a greater distance than a quarter of a mile from the traps, and that some were very close to the traps and had obviously resulted from eggs laid by females which had escaped from the traps. In the case of attack 8 and 9 (Appendix II), Sahri trap, E, was visited by Mr. Pal at night on October 16th and a number of moths were found to be escaping from that trap, but this was stopped by decreasing the size of the openings and by other minor adjustments

That the percentage of moths which escape from the traps is not a high one can be seen from the figures given below :—

Total moths caught in the traps	...	...	...	=152,622
Total caterpillars picked	...	...	...	=107,439

Parent moths required to produce above caterpillars at the rate of 300 eggs per female moth $= \frac{107,439 \times 2}{300} = 716.$

$\therefore$ Percentage escapes $= \frac{716 \times 100}{152,622} = 0{\cdot}46$ per cent. (or 1 moth in two hundred.)

The objection raised in Egypt to the traps on account of the distance from which they draw moths is not a serious one at Mokameh, where the traps are required to attract moths from as great a distance as possible. The long range of the traps is shown by the fact that in only one case were any caterpillars found at any great distance from the traps, and in this case the attacked area was two miles from the traps. All the other attacks were probably caused by moths which had escaped from the traps. The fact that only one moth in two hundred escaped from the traps on the *tal* during the year shows that the traps must possess a very wide radius of action when it is considered that the traps were situated at a distance of from four hundred to two thousand yards apart (*vide* Appendix IV). Provided the traps collect the moths from all over the *tal*, effectively, there is very little to complain of in having a few small attacked areas near the traps, where they can easily be found and picked. The damage done by the caterpillars on such areas if picked in time is usually slight.

Enough has now been said to show that the Andres Maire traps would appear to be more efficient under the conditions prevailing at Mokameh than in Egypt. It now remains to consider the cost of the campaign.

The statement below gives both the non-recurring expenditure on the initial cost of the traps and also the recurring expenditure incurred in conducting the present campaign. Details of pay and travelling allowance of the permanent staff deputed to

conduct the campaign and of the travelling allowance of the supervising staff at Sabour are also included :—

		Rs. As. P.	
(1)	Non-recurring expenditure :—		
	Cost of 24 traps—materials and freight ...	721 0 0	
	Labour	457 8 0	
	Freight to Mokameh ...	100 15 0	
	Total cost ...		1,279 7 0
(2)	Recurring expenditure :—		
	Pay of trap operators and coolies for 4½ months ...	380 10 0	
	Handpicking caterpillars	158 14 0	
	Cooly and cart hire	172 9 9	
	Chemicals for preparing Prodenine	136 6 0	
	Miscellaneous	184 12 0	
	Total cost ...		1,033 3 9
(3)	Pay of Demonstrator in Entomology, Divisional Inspector and permanent menials deputed to Mokameh	747 0 0	
	Travelling allowance of Govt. Officers (including Sabour staff)	770 0 0	
	Total cost ...		1,517 0
	GRAND TOTAL ...		3,829 10 9

From the above figures it will be seen that Rs. 3,829 has been spent on saving the crop on 10,000 acres, the cost per acre therefore works out at Rs. 0-6-0 (6*d.*) per acre. It may be necessary to slightly increase this working cost in future years by adding to the number of traps on the Mokameh and Pali *tals*. On the other hand, it may be found that the number of insects on the *tal* will diminish in the course of a few years.

In the present paper no attempt has been made to consider the life history of the pest, but it will be sufficient to say that it is not unlikely that it will be found that *Agrotis ypsilon* does æstivate on the *tal*. This and other questions have been dealt with at greater length in a report in the Agricultural Journal of the Bihar Department of Agriculture, Vol. I, No. 2.

Summary.

An account is given of a campaign in which the Andres Maire moth traps were used on a large scale to check the damage caused annually by Agrotis on ten thousand acres of the Mokameh *tal.* It is claimed that the traps have been completely successful in checking the pest. In the year under review less than one hundred acres were damaged by Agrotis, while more than sufficient insects were destroyed to account for the destruction of the crop over the normally attacked area. The traps appear to be more efficient at Mokameh than in Egypt because they attract all the Agrotis moths within a very wide radius: they attract gravid females as well as males; the number of moths which escape is slight (probably in the neighbourhood of one moth in every two hundred caught), but the caterpillars derived from these escaped moths usually appear near the traps and so can easily be found and picked off.

As regards the economic results of the season's work, it is claimed that a crop worth over £20,000 has been secured by the investment of £ 255 in preventative measures.

Appendix I.

Statement of catches in the traps. March to December.

March 1912.

Date.	Agrotis male.	Agrotis female.	Total of the day.	Weather conditions.	Direction of wind.	Number of traps employed.	Remarks.
1-3-12 ...	1	5	6	Fair.	N. W.	1 trap throughout month at Paijuna.	No detailed records.
2-3-12 ...	0	1	1	,,	,,	...	
3-3-12 ...	...	...	...	...	...	...	
4-3-12 ...	...	...	...	...	...	...	
5-3-12 ...	...	...	...	...	...	...	
6-3-12 ...	...	...	...	...	...	...	
7-3-12 ...	18	20	38	...	...	...	
8-3-12 ...	...	...	...	...	...	...	
9-3-12 ...	...	...	...	...	...	...	
10-3-12 ...	...	...	...	...	...	...	
11-3-12 ...	...	...	...	...	...	...	
12-3-12 ...	...	...	...	...	...	...	

APPENDIX I. *March—(contd.)*

DATE.	Agrotis male.	Agrotis female.	Total of the day.	Weather conditions.	Direction of wind.	Number of traps employed.	REMARKS.
13-3-12 ...	1	3	4	Fair.	N. W.		
14-3-12 ...	0	2	2	,,	,,		
15-3-12 ...	3	3	6	,,	,,		
16-3 12 ...	1	2	3	,,	,,		
17-3-12 ...	2	3	5	,,	,,		
18-3-12 ...	1	2	3	Rainy.	,,		
19-3-12 ...	0	2	2	Cloudy.	,,		
20-3-12 ...	0	0	0	Fair.	,,		
21-3-12 ...	1	2	3	,,	,,		
22-3-12 ...	0	2	2	,,	,,		
23-3-12 ...	1	2	3	,,	,,		
24-3-12 ...	0	0	0	,,	,,		
25-3-12 ...	0	0	0	,,	,,		
26-3-12 ...	0	2	2	,,	,,		
27-3-12 ...	1	1	2	,,	N. E.		
28-3-12 ...	1	2	3	Rainy.	,,		
29-3-12 ...	0	2	2	Fair.	,,		
30-3-12 ...	1	1	2	Cloudy.	N.		
31-3-12 ...	0	2	2	Fair.	N. E.		

April 1912.

1-4-12 ...	1	2	3	Fair.	N. W.	1 trap throughout month at Paijuna.	
2-4-12 ...	1	1	2	,,	N. E.		
3-4-12 ...	0	0	0	,,	N. W.		
4-4-12 ...	1	1	2	,,	,,		
5-4-12 ..	0	1	1	,,	,,		
6-4-12 ...	1	2	3	,,	,,		
7-4-12 ...	0	0	0	,,	,,		
8-4-12 ...	1	2	3	,,	,,		
9-4-12 ...	0	0	0	,,	,,		
10-4-12 ...	1	2	3	,,	,,		
11-4-12 ...	1	1	2	,,	N. E.		
12-4-12 ...	0	0	0	,,	N. W.		
13-4-12 ...	1	2	3	,,	,,		
14-4 12 ..	0	0	0	,,	,,		
15-4-12 ...	Records not received.			...	...		
16-4-12 ...	0	0	0	Rainy.	N. E.		
17-4-12 ...	0	1	1	Fair.	N. W.		
18-4-12 ...	1	2	3	,,	N. E.		
19-4-12 ...	0	0	0	,,	,,		
20-4-12 ...	1	1	2	,,	,,		
21-4-12 ...	0	1	1	,,	,,		
22-4-12 ...	0	0	0	,,	,,		
23-4-12 ...	0	2	2	,,	,,		
24-4-12 ...	0	2	2	,,	,,		
25-4-12 ...	0	0	0	,,	,,		
26-4-12 ...	0	0	0	,,	,,		
27-4-12 ...	0	0	0	,,	,,		
28-4-12 ...	0	1	1	,,	,,		
29-4-12 ...	Records not received.			...	...		
30-4-12 ..	0	0	0	,,	,,		

During May, June and July there were no catches in the trap.

Appendix I—(*contd.*)

August 1912.

Date.		Agrotis male.	Agrotis female.	Total of the day.	Weather conditions.	Direction of wind.	Number of traps employed.	Remarks.
1-8-12	...	0	0	0	Fair.	N. E.	1 trap at Paijuna.	
2-8-12	...	0	0	0	,,	,,	,,	
3-8-12	...	0	0	0	,,	,,	,,	
4-8-12	...	0	0	0	,,	,,	,,	
5-8-12	...	0	0	0	,,	,,	,,	One additional small trap was worked inside a basti throughout the month. No Agrotis was caught in it.
6-8-12	...	0	0	0	,,	,,	,,	
7-8-12	...	0	0	0	Rain.	N. W.	,,	
8-8-12	...	0	0	0	,,	,,	,,	
9-8-12	...	0	0	0	,,	,,	,,	
10-8-12	...	0	0	0	Fair.	,,	,,	
11-8-12	...	0	0	0	,,	,,	,,	
12-8-12	..	0	0	0	Rain.	,,	,,	
13-8-12	...	0	0	0	,,	,,	,,	
14-8-12	...	0	0	0	,,	,,	,,	
15-8-12	...	0	0	0	,,	,,	,,	
16-8-12	...	0	0	0	,,	,,	,,	
17-8-12	...	0	0	0	,,	,,	,,	
18-8-12	...	0	4	4	,,	,,	,,	
19-8-12	...	0	0	0	,,	,,	,,	
20-8-12	...	0	0	0	,,	,,	,,	
21-8-12	..	0	0	0	,,	,,	,,	
22-8-12	...	0	0	0	,,	,,	,,	
23-8-12	...	0	1	1	,,	,,	,,	
24-8-12	..	0	0	0	Fair.	,,	,,	
25-8-12	..	0	0	0	Rain.	,,	,,	
26-8-12	...	0	0	0	,,	,,	,,	
27-8-12	...	0	1	1	,,	N. E.	,,	
28-8-12	..	0	0	0	,,	,,	,,	
29-8-12	...	0	0	0	,,	,,	,,	
30-8-12	...	1	2	3	,,	,,	,,	
31-8-12	.	3	2	5	,,	,,	,,	

September 1912.

Date.		Agrotis male.	Agrotis female.	Total of the day.	Weather conditions.	Direction of wind.	Number of traps employed.	Remarks.
1-9-12	...	0	6	6	Fair.	E.	2 traps.	
2-9-12	...	1	6	7	Rain.	N. W.	,,	
3-9-12	...	2	10	12	Fair.	Dull.	,,	
4-9-12	...	2	8	10	Cloudy.	N. W.	3 ,,	
5-9-12	...	21	44	65	,,	S.	5 ,,	
6-9-12	...	67	101	168	Rain.	S. E.	6 ,,	
7-9-12	..	180	313	493	,,	,,	6 ,,	
8-9-12	...	255	488	743	,,	W.	6 ,,	
9-9-12	...	287	499	786	Cloudy.	W.	6 ,,	
10-9-12	...	385	459	844	Rain.	S. W.	7 ,,	
11-9-12	...	221	281	502	Fair.	,,	8 ,,	
12-9-12	...	131	160	291	,,	W.	8 ,,	
13-9-12	...	73	82	155	,,	W.	8 ,,	
14-9-12	..	74	77	151	,,	W.	8 ,,	
15-9-12	...	39	61	100	,,	S. W.	8 ,,	
16-9-12	...	55	67	122	,,	,,	10 ,,	
17-9-12	...	37	49	86	,,	,,	,, ,,	
18-9-12	...	79	77	156	,,	,,	14 ,,	
19-9-12	...	116	111	227	,,	,,	,, ,,	
20-9-12	...	70	97	167	,,	,,	,, ,,	
21-9-12	...	147	179	326	,,	,,	20 ,,	
22-9-12	...	316	374	690	,,	,,	,, ,,	
23-9-12	.	301	310	611	,,	S. E.	21 ,,	
24-9-12	...	240	252	492	,,	,,	,, ,,	
25-9-12	..	293	341	634	,,	,,	,, ,,	
26-9-12	...	306	374	680	,,	,,	,, ,,	
27-9-12	...	531	634	1,156	Cloudy.	N. E.	,, ,,	
28-9-12	...	502	703	1,205	,,	S. E.	,, ,,	
29-9-12	...	761	1,279	2,040	,,	S. W.	,, ,,	
30-9-12	...	981	1,137	2,118	,,	,,	,, ,,	

APPENDIX I—(*contd.*)

October 1912.

DATE.		Agrotis male.	Agrotis female.	Total of the day.	Weather conditions.	Direction of wind.	Number of traps employed.	REMARKS.
1-10-12	...	488	631	1,119	Fair.	S. E.	21 traps.	
2-10-12	...	635	891	1,526	Rain.	,,	,,	
3-10-12	...	617	741	1,358	Cloudy.	,,	,,	
4-10-12	...	788	1,152	1,940	Foggy.	,,	,,	
5-10-12	...	2,258	2,479	4,737	Fair.	S. W.	,,	
6-10-12	...	3,175	3,526	6,701	,,	,,	,,	
7-10-12	...	2,697	3,176	5,873	Cloudy.	,,	,,	
8-10-12	...	2,500	3,354	5,854	Fair.	,,	,,	
9-10-12	...	2,339	2,818	5,157	,,	S. E.	,,	
10-10-12	...	1,835	1,988	3,823	,,	N. W.	22 ,,	
11-10-12	...	906	971	1,877	,,	W.	,,	
12-10-12	...	863	926	1,789	,,	,,	,,	
13-10-12	...	671	812	1,483	,,	,,	,,	
14-10-12	...	662	709	1,371	,,	,,	,,	
15-10-12	...	576	705	1,281	,,	S. W.	,,	
16-10-12	...	556	626	1,182	,,	,,	,,	
17-10-12	...	500	563	1,063	,,	,,	,,	
18-10-12	...	472	431	903	,,	,,	,,	
19-10-12	...	383	371	754	,,	,,	,,	
20-10-12	...	336	384	720	,,	W.	,,	
21-10-12	..	375	347	722	,,	N. E.	,,	
22-10-12	...	485	322	807	,,	N. W.	,,	
23-10-12	...	428	174	602	,,	S. W.	,,	
24-10-12	...	297	238	535	,,	W.	,,	
25-10-12	...	282	191	473	,,	,,	,,	
26-10-12	...	270	157	427	,,	S. W.	,,	
27-10-12	...	279	225	504	,,	,,	,,	
28-10-12	...	278	181	459	,,	W	,,	
29-10-12	...	288	135	423	,,	N. E.	,,	
30-10-12	...	315	144	459	,,	,,	,,	
31-10-12	...	643	258	901	Cloudy.	,,	,,	

November 1912.

DATE.		Agrotis male.	Agrotis female.	Total of the day.	Weather conditions.	Direction of wind.	Number of traps employed.	REMARKS.
1-11-12	...	...	....	...	Cyclonic.	E.	...	No records taken.
2-11-12	...	1,184	233	1,417	Cloudy, drizzling.	E.	22 traps.	
3-11-12	...	1,128	395	1,723	Dull, cloudy.	N. W.	,,	
4-11-12	...	1,208	322	1,530	Dull, fair.	,,	,,	
5-11-12	...	1,488	770	2,258	Fair.	,,	,,	
6-11-12	...	2,047	622	2,669	,,	N. E.	23 ,,	
7-11-12	...	2,588	848	3,436	,,	N. W.	,,	Antennæ adopted as critical character for diagnosing females.
8-11-12	...	2,692	995	3,687	,,	,,	,,	
9-11-12	..	2,509	915	3,424	,,	,,	,,	
10-11-12	...	2,029	757	2,786	,,	,,	,,	
11-11-12	...	1,562	770	2,332	Dull.	,,	,,	
12-11-12		1,679	1,097	2,776	Cloudy.	,,	,,	
13-11-12	...	1,402	1,154	2,556	,,	,,	,,	
14-11-12	...	1,404	937	2,341	,,	N. E.	,,	
15-11-12	...	1,454	641	2,095	Fair.	N. W.	,,	
16-11-12	...	1,461	673	2,134	,,	,,	,,	
17-11-12	...	1,030	611	1,641	,,	W.	,,	
18-11-12	..	678	411	1,089	,,	,,	25 ,,	
19-11-12	...	1,170	638	1,808	,,	,,	,,	
20-11-12	...	565	359	924	,,	N. W.	,,	
21-11-12	...	387	239	626	,,	,,	,,	
22-11-12	...	485	274	759	Cloudy.	,,	,,	

APPENDIX I. *November—(concluded).*

DATE.	Agrotis male.	Agrotis female.	Total of the day.	Weather conditions.	Direction of wind.	Number of traps employed.	REMARKS.
23-11-12 ...	...	...	...	Cyclonic	...	..	Traps not worked.
24-11-12 ...	1,736	1,048	2,784	Rain.	E.	25 traps.	
25-11-12 ...	1,234	613	1,856	Cloudy.	N. W.	,,	
26-11-12 ...	1,191	639	1,830	Fair.	W.	,,	
27-11-12 ...	1,571	980	2,551	,,	S. W.	,,	
28-11-12 ...	1,766	1,250	3,016	,,	W.	,,	
29-11-12 ...	1,562	1,052	2,614	,,	,,	,,	
30-11-12 ...	1,601	1,146	2,747	,,	,,	,,	
December 1912.							
1-12-12 ...	952	634	1,586	Fair.	W.	25 traps.	
2-12-12 ...	948	682	1,630	,,	,,	,,	
3-12-12 ...	789	480	1,269	,,	,,	,,	
4-12-12 ...	976	620	1,596	,,	,,	,,	
5-12-12 ...	930	572	1,502	,,	N. W.	,,	
6-12-12 ...	798	498	1,296	Cloudy.	N. E.	,,	
7-12-12 ...	788	431	1,219	Fair.	N. W.	,,	
8-12-12 ...	556	343	899	,,	S. W.	,,	
9-12-12 ...	479	302	781	,,	W.	,,	
10-12-12 ...	405	234	639	,,	,,	,,	
11-12 12 ...	475	283	758	,,	,,	,,	
12-12-12 ...	399	248	647	,,	N. W.	,,	
13-12-12 ...	341	254	595	,,	,,	,,	
14-12-12 ...	334	230	564	,,	W.	,,	
15-12-12 ...	336	220	556	,,	,,	,,	
16-12-12 ...	243	140	383	,,	,,	,,	
17-12-12 ...	240	104	344	,,	,,	,,	
18-12-12 ...	188	125	313	Cloudy.	,,	,,	
19-12-12 ...	171	93	264	Fair.	,,	,,	
20-12-12 ...	146	89	235	,,	,,	,,	
21-12-12 ...	123	65	188	,,	,,	,,	
22-12-12 ...	131	73	204	,,	,,	,,	
23-12-12 ...	133	82	215	,,	,,	,,	
24-12-12 ...	100	41	141	,,	,,	,,	
25-12-12 ...	85	66	151	,,	,,	,,	
26-12-12 ...	109	61	170	,,	S. E.	,,	
27-12-12 ...	105	54	159	,,	,,	,,	
28-12-12 ...	88	46	134	,,	N. W.	,,	
29-12-12 ...	66	57	123	,,	W.	,,	
30-12-12 ...	68	53	121	,,	N. E.	,,	
31-12-12 ...	74	55	129	,,	,,	,,	

Summary of catches in all traps.

Name of month.	Total number of Agrotis moths caught during the month.	Average number of moths caught per night per trap.	REMARKS.
September	14,983	*	Average cannot be accurately calculated as the traps were being set up one by one as water receded.
October	56,823	113·9	
November	61,409	89·8	
December	18,811	24·2	
January (6 days)	392	2·6	

* From the records for the last 11 days of September (from 20th) the average per night per trap is 48·5.

Appendix II.

Statement of caterpillar attacks.

Name of tal.	Owner of field.	Kita.	Distance from nearest trap.	Size of area attacked.	Number of caterpillars picked and stages of caterpillars.	Dates of picking.	Dates of sowing of attacked field.	Net damage from Agrotis.
1. Mokameh (Tirmohon side).	Feringhi Coomar ...	Utra Dakhina ...	60 yds. from D. E.	2 bighas	610—2nd & 3rd stages ...	Oct. 21	30-9-12	1 anna.
2. Do. ...	Feringhi Singh ..	Sakhwa-Kolba ...	60 yds. from T. D.	9 ,,	13,545—2, 3, & 4th stages	Oct. 14, 16, 17, 22, 23 & 24	28-9-12	8 annas.
3. Do. ..	(Resident of Auta) ...	Punrerh ..	300 yds. from T. D.	18 ,,	10,349 ,, ...	Oct. 19, 20, & 21	1-10-12	,,
4. Do. ...	Nursing Singh ...	Do. ...	350 yds. from T. D.	4 ,,	8,460 ,, ...	Oct. 25 & 26	5-10-12	,,
5. Do. ...	Punhit Mahto ...	Do. ...	400 yds. from T. D.	8 ,,	* ,, ...	*	6-10-12	14 ,,
6. Do.	Sheo Sahai Singh ..	Chauradih ..	150 yds. from T. E.	7 ,,	7,370 ,, ...	Oct. 26 & 27	8-10-12	8 ,,
7. Do. ..	Babu Lal Singh ...	Darapur ...	400 to 500 yds. from T. F.	2 ,,	8,747—3rd & 4th stages...	Oct. 31	8-10-12	4 ,,
8. Sahri side ...	Harku Lal ...	Belchanda ...	50 yds. from S. E.	2 ,,	671—2, 3, 4th stages ...	Oct. 20, 21 & 22	1-10-12	8 ,,
9. Do. ..	Kashi Mahto ..	Lachhantika ...	200 yds. from S. E.	10 ,,	8,188 ,, ...	Oct. 23, 24, 25, 30 & 31	1-10-12	6 ,,
10. Burhee (Pali side).	Raghunandan and Gajo Singh.	Taurah ...	10 to 300 yds. from P. D.	17 ,,	44,333 ,, ...	Oct. 19, 21, 23, 29, 30 & 31	28, 29, 30-9-12	8 ,,
11. Do. ..	Bhanu Mahto ...	Simana ...	2 miles from nearest trap in Pali.	3 ,,	5,166—3 and 4th stages	Oct. 22	8-10-12	4 ,,

* No picking was done. *N.B.*—1 bigha = $\frac{2}{3}$ acre approx.

APPENDIX III.

Statement showing proportion of male and female moths caught in the traps.

Number of Trap.	December.			November.			October.			September.			Remarks.
	Total No. of males caught.	Total No. of females caught.	Proportion of males to females caught.	Total No. of males caught.	Total No. of females caught.	Proportion of males to females caught.	Total No. of males caught.	Total No. of females caught.	Proportion of males to females caught.	Total No. of males caught.	Total No. of females caught.	Proportion of males to females caught.	
D. A.	431	757	1:1·76	610	777	1:1·27	1,195	563	2·12:1	261	152	1·71:1	
D. B	557	871	1:1·56	1,897	1,844	1·03:1	2,765	2,094	1·32:1	427	321	1·33:1	
D. C	...	...	...	108	123	1:1·14	176	90	1·95:1	5	12	1:2·4	
D. D.	...	...	...	61	86	1:1·41	781	318	2·45:1	81	70	1·15:1	
D. E.	...	...	...	...	...	...	748	407	1·83:1	473	330	1·43:1	
Pj. A.	506	827	1:1·63	766	967	1:1·26	519	277	1·87:1	81	77	1·05:1	
Pj. B.	26	61	1:2·35	428	333	1·28:1	605	310	1·95:1	64	61	1·05:1	
Pj. C.	169	220	1:1·30	598	491	1·21:1	819	375	2·18:1	83	82	1:1	
S. A.	235	289	1:1.23	1,183	969	1·22:1	1,095	786	1·38:1	189	145	1·30:1	
S. B.	300	340	1:1·13	1,117	1,573	1:1·41	1,510	794	1·90:1	189	117	1·61:1	
S. C.	189	272	1:1·42	821	952	1:1·16	909	640	1·42:1	200	193	1·04:1	
S. D.	191	221	1:1·15	1,391	1,208	1·15:1	1,126	938	1·20:1	214	177	1·19:1	
S. E.	278	300	1:1·08	1,278	1,152	1·11:1	1,172	784	1·49:1	206	114	1·80:1	
S. F.	246	351	1:1·42	1,247	1,070	1·17:1	1,321	765	1·72:1	223	158	1·41:1	
T. A.	532	611	1:1·15	986	1,149	1:1·16	1,988	958	2·07:1	495	330	1·50:1	
T. B.	577	639	1:1·10	1,502	1,453	1·03:1	1,477	784	1·88:1	141	133	1·06:1	
T. C.	809	963	1:1·19	1,822	1,767	1·03:1	2,442	1,160	2·10:1	590	419	1·40:1	
T. D.	382	441	1:1·15	1,903	2,155	1:1·13	1,565	1,023	1·54:1	518	442	1·15:1	
T. E.	515	460	1:12·1	2,203	2,212	1:1	2,557	1,149	2·22:1	1,073	714	1·50:1	
T. F.	...	...	...	...	...	...	1,445	905	1·60:1	508	353	1·42:1	
T. G.	...	...	...	...	...	...	900	786	1·15:1	448	322	1·39:1	
P. A.	115	181	1:1·57	1,964	2,279	1:1·16	3,473	1,076	3·22:1	772	362	2·13:1	
P. B.	58	111	1:1·91	1,628	2,146	1:1·31	3,380	1,098	3·08:1	1,175	568	2·07:1	
P. C.	210	286	1:1·36	1,870	2,415	1:1·29	3,378	1,099	3·08:1	1,475	703	2·09:1	
P. D. ...	133	185	1:1·39	1,866	2,524	1:1·35	3,794	1,235	3·07:1	1,692	881	1·99:1	
TOTAL ...	6,459	8,386	...	27,249	29,645	...	41,130	20,324	.	11,573	7,236	..	
Average proportion ...	...	...	1:1·29	...	...	1:1·09	...	...	2·02:1	...	...	1·6:1	
Percentage of females to total moths caught	...	...	56·5%	...	...	52·1%		..	33·07%			38·4%	

N.B.—The antennæ were used as the critical character for diagnosing the sex of the moths from 7th November 1912.

Appendix IV.

Statement showing distance apart of traps.

Distance between	Pj. A. and Pj. B.	... ...	410 yards.
Do. do.	Pj. A. and Pj. C.	... .	1,300 ,,
Do. do.	Pj. C. and S. C.	... ...	600 ,,
Do. do.	S. C. and S. B.	... .	780 ,,
Do. do.	S. B. and S. A.	... ...	1,020 ,,
Do. do.	S. A. and S. D.	... ...	1,020 ,,
Do. do.	S. D. and S. E.	... ...	640 ,,
Do. do.	S. E. and S. F.	... ...	510 ,,
Do. do.	T. A. and T. B.	... ...	600 ,,
Do. do.	T. B. and T. C.	... ...	1,130 ,,
Do. do.	T. C. and T. D.	... ...	00 ,,
Do. do.	T. D. and T. E.	... ...	700 ,,
Do. do.	T. E. and T. F.	... ...	1,300 ,,
Do. do.	T. F. and T. G.	.. . ...	720 ,,
Do. do.	T. G. and D. E.	... ...	750 ,,
Do. do.	D. E. and D. B.	... ...	750 ,,
Do. do.	D. B. and D. A.	... ...	750 ,,
Do. do.	D. A. and D. C.	.. ..	2,800 ,,
Do. do.	D. C. and D. D.	... .	1,500 ,,
Do. do.	P. A. and P. D.	... .	1,100 ,,
Do. do.	P. D. and P. B.	... ...	1,700 ,,
Do. do.	P. B. and P. C.	... .	1,950 ,,

NOTES.

SIDE LIGHTS ON "DRY-FARMING."—The following abstract of Bulletin No. 98 of the United States Department of Agriculture, is taken from the Bulletin of Agricultural Intelligence and Plant Diseases issued by the International Institute of Agriculture, May, 1913 :

"In the semi-arid regions of the United States, which have been made productive by the adoption of the dry-farming system, large yields of crops are obtained with an apparently totally insufficient moisture supply in the shape of an annual rainfall of 15 inches ; and the present bulletin sets forth the result of an enquiry into how far this insufficient rainfall is supplemented by an underground water-supply.

"In South Dakota the soils are derived from the underlying clays and shales, and where the latter are exposed in wells, railway cuttings, etc., they are moist almost to the point of saturation, and the moisture increases uniformly with the distance from the surface, suggesting a subterranean rather than a superficial source of supply. The whole district may be looked upon as an artesian area with a catchment area on the Eastern Slopes of the Rocky Mountains, whence the Dakota sandstone conveys the water to South Dakota, the water gradually leaking into and through the overlying clays and shales. The rate of percolation and seepage cannot be accurately stated pending systematic observation, but it has been provisionally estimated at over 12 inches per annum—sufficient to supplement the 15 inches of rainfall and produce an abundant crop.

"Another portion of the region of the Great Plains was studied in South-Western Kansas, and a detailed description of

the ground-water condition is given. The conclusion is drawn that the district is underlain by a reservoir of moisture flowing eastward, and derived both from the local rainfall and from catchment on the mountains or higher parts of the plains. The water table occasionally comes to the surface and gives rise to perennial streams and permanent ponds, but though within reach of the surface by capillary movement, it usually lies at an average depth of 30 feet, and may be considerably lowered by excessive use. A provisional estimate was made that 6 to 8 inches of water per annum would rise from the underground supply and be available for plant growth.

"It would be difficult to overestimate the importance of these results, for the areas where the subterranean movement and supply of water are indicated coincide with those where dry-farming has been most successful, and it may be inferred that there is a close connection between the two phenomena. Moreover, if this be the case, it will also explain why the system yields so far less satisfactory results when applied to other parts of the world where different geological conditions obtain."

* * *

A Promising Variety of Soy Beans.—At the time when our Memoir* on the subject of Soy Beans was published we were not in a position to recommend any particular variety, but it would now appear that the Nepali variety is likely to prove a paying crop for cultivation in the Himalayas at an elevation of about four to five thousand feet.

The Nepali variety was first tested on the Kalimpong farm where it yielded at the rate of nearly 1 ton ($26\frac{1}{2}$ mds.) of seed per acre in 1911. In 1912 its yield is given by the Superintendent of the Farm, Mr. J. Wilson, as 1,170 lbs. ($14\frac{1}{4}$ mds.), and this will probably prove to be more nearly its average yield. It is a short stout upright variety with short branches close pressed

* Woodhouse, E. J., and Taylor, C. S.—The Varieties of Soy Beans found in Bengal, Bihar and Orissa and their Commercial Possibilities. Mem. Dept. of Agri. in India, Bot. Ser., V, No. 3.

to the stem, and this habit is of advantage in that it enables the crop to be weeded more efficiently and economically than in the case of the more common twining types. The variety appears to be able to grow at slightly higher elevations than the other types and is quite unsuited to cultivation in the plains of India. It should be planted as a pure and not as a mixed crop if satisfactory results are to be obtained.

As regards the value of the crop for export, it must be remembered that the value of Soy Beans for commercial purposes depends on the seeds being large and of a pale colour and possessing a low moisture and high oil content. South Russia has supplied the best beans ever put on the English market and a sample of these beans has been procured through the courtesy of Messrs. Kilburn & Co., of Calcutta. A recent comparison of the Nepali and South Russian seed shows that the Nepali variety, as grown in the Himalayas, weighs distinctly heavier than the Russian seed, but the Russian seed has a very slightly larger oil content (19°/₀ as compared with 18·5°/₀). There is not likely to be any complaint as regards excessive moisture content if the seeds are properly dried in the plains of India before despatch. The only real disadvantage possessed by the Nepali seed is its brown colour, which is likely to injure the colour of meal made from it.

A statement of the results of analysis of these two varieties and of a typical twining variety is given below :

Variety.	South Russian.	Lal Bhetmas (type IV).	Nepali (type VI).
% Oil content ...	18·95	15·6 to 17·3	17·9 to 20·4
% Nitrogen content ...	6·09	5·6 to 6·1	6·60 to 6·88
Weight of 100 seeds ...	21·5 gr.	4·41 to 6·5	24·4 to 29·6
Colour	Pale yellow.	Brown.	Brown.

The above figures are sufficient to prove that India is capable of producing as good a quality of Soy Bean as can be produced anywhere else, but it cannot be expected that the seed will fetch its full market value unless arrangements are made for growing

and marketing large quantities of the beans in favourable localities.—(E. J. WOODHOUSE.)

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INDUSTRIAL ALCOHOL.—A great deal has been written lately in favour of the use of alcohol as a petrol substitute, the high prices recently prevailing having stimulated enquiries in this direction.

Now as the general adoption of alcohol as a fuel would clearly bring machines into direct competition with man and animals, as consumers of agricultural products from which alcohol is produced, and might raise in an acute and definite form the question of the economic value of human life, it is not a prospect to be lightly considered.

The following extract from the *Indian Trade Journal* presents one side of the question :—" In the course of a paper on "Petrol Substitutes" by Sir Boverton Redwood and Professor Vivian B. Lewes read at the Imperial Motor Transport Conference the authors remarked :—" Any petrol substitutes made from petroleum, coal, or shale were obtainable only in limited quantity, for in each case the store of raw material was in process of depletion. On the other hand, alcohol was a motor spirit which could be continuously manufactured in any required quantity, and if the Imperial Motor Transport Conference only realized this fact and used its influence in the first place to stimulate the designing of an engine and carburettor best fitted for use with this liquid, and secondly, to induce the Government to give the necessary facilities for the manufacture and use of methylated spirit for the purpose, it would have done much towards giving this country a home-produced source of power of which no foreign entanglements could rob us. By fermentation in bulk, continuous distillation, and judicious methylation all the motor spirit needed could be obtained and sold at something like 1s. a gallon, and the extended researches of the United States Government had shown that engines could be satisfactorily run on alcohol, while in spite of the calorific inferiority of alcohol practically the same power was generated as with petrol, owing to the cooler cycle, smaller quantity of air required, and greater

compression that could be used without fear of pre-ignition. Thousands of acres of land fitted for the growth of potatoes and beet were lying idle in Ireland, even in England, and when it was demonstrated to the satisfaction of the Government that the motor was ready for the new fuel the required facilities could no longer be withheld."

The fallacy of the argument can however be illustrated by an extract from a Bulletin (Farmers' Bulletin No. 429), issued by the United States Department of Agriculture, in 1911, on "Industrial Alcohol, sources and manufacture." Under the heading *Fuel* we are told :—"Little definite information is available regarding the amount of fuel necessary for the operation of a small alcohol distillery. This dearth of accurate knowledge is regrettable, for the coal bill is a prominent item in the distillery's expense account. Such data as are at hand indicate that the coal consumption—per gallon 180° alcohol produced—may vary from 11 pounds under the most favourable conditions to 38 pounds in a poorly equipped and poorly managed plant. As 11 pounds of coal as a distillery fuel yield almost 159,000 heat units and a gallon of alcohol gives about 75,000, it is apparent that the use of alcohol so produced for heating would involve a great waste and be altogether unprofitable. The coal consumption of a small distillery will be proportionally greater than that of a large one since many economies which are possible in a large plant are quite impracticable in a small one."

It would seem that as long as two heat units in coal have to be used merely to help in the concentration of one in alcohol, the use of the latter is not truly economical. It is surely better to direct attention to the economies possible in the consumption of coal, by its own resolution, by distillation, into specialized fuels, than to contemplate what might conceivably become a premature, literal taking of the bread out of the mouths of the poor in order to get over an ephemeral difficulty : a solution of which, more economical than the wholesale conversion of edible products into fuel by the methods at present available, is obviously possible.—(A. C. DOBBS.)

REVIEWS.

(*a*) Practical Agricultural Chemistry, by S. J. M. Auld and D. R. Edwardes-Ker: Published by John Murray. (Price 5 shillings.)

(*b*) A Foundation Course in Chemistry for Students of Agriculture and Technology, by J. W. Dodgson and J. A. Murray: Published by Longmans, Green & Co. (Price 3*s.* 6*d.*)

These two new text-books have been recently received. Considering, first, Auld and Edwardes-Ker's volume—it forms a very useful collection of experimental exercises for the student of Agricultural Chemistry, and is in fact one of the most complete works of the kind which have appeared. As the title indicates only the practical side is dealt with, theoretical matters being chiefly omitted. The illustrations are good.

Referring secondly to the little work by Messrs. Dodgson and Murray, it is difficult to mete out a like measure of praise to it. Although only a small volume. the attempt is made to cover both theoretical as also practical chemistry within its limits, with the inevitable result that neither is well done.

Speaking generally, such works as these are not very suitable for the student of the Indian Agricultural College of to-day. Whilst in Europe and America such students have, in a fairly high proportion of cases, a good knowledge of practical agriculture and gain much from a college course of science : here, in India, the present day student is usually hopelessly ignorant of agriculture and must, if he is to become of service agriculturally, devote the major part of his time to practical agriculture. The most he can properly attempt in chemistry is a very limited course which

may enable him to understand what the science deals with, and he could not be expected to assimilate more than a small part of the matter which either of these text-books includes.—(J. W. L.)

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A feature of recent numbers of the monthly *Bulletin of Agricultural Intelligence and Plant Diseases* has been the inclusion of original articles by eminent authorities on prominent agricultural questions. The June issue contains some particularly interesting articles, including two on the Swedish Crop Improvement work, by the Head of the Svalöf Institute and by Dr. Nilsson-Ehle, one of the workers, and an article on motor cultivation in Germany by Dr. Gustav Fischer, Professor of the Royal Agricultural Higher School in Berlin.

The former shew how, in spite of the apparent simplification effected by the use of the facts discovered by Mendel, the work of plant improvement is frequently complicated by the appearance of numerous cognate characters tending in similar directions, which, at the same time, open out a prospect of correspondingly close adjustment to environmental conditions.

Dr. Fischer gives an account of the development of motor ploughs in Germany, since 1910, due to the initiative of Robert Stock. The best of these ploughs appear to do thoroughly satisfactory work, but the significant statement is made that "it is usual to calculate, for interest, amortizement and repairs, 25 per cent. of the purchase price."—(A. C. D.)

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Publications of Provincial Agricultural Departments.

The Central Provinces Agricultural and Co-operative Gazette for June maintains the interest of preceding numbers. Part I—Agriculture, contains a further instalment of Major Baldrey's lecture on Cattle of the Central Provinces; an article on the Eradication of ticks; and a note on the "Nerbudda" Reaper, an adaptation of the "Rajah" to suit local conditions, and of which the 15 machines available for sale before the last harvest were immediately disposed of.

In Part II—Co-operation, the Registrar's Notes give a vivid idea of the difficulties of instilling business principles into the working of loan societies. The issue closes with an account by the Assistant Registrar, Misbahul Osman, of Schulze-Delitzsch, one of the German pioneers of co-operation.

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THE concluding number of the fourth volume of the *Poona Agricultural College Magazine* opens with an editorial "puff" of the contents which stimulates criticism.

There is an interesting note by Mr. H. M. Chibber on some Promising Leguminous Crops—a tuberous rooted climber *Pachyrhizus angulatus* and the Mozambique Bean (*Voandzeia subterranea*). Other articles of local interest include 'Notes on the Cottons of Khandesh' by K. D. Kulkarni, and 'Artificial Manures in the Karnatak' by G. L. Kottur.

An article on the Determination of Ripeness in Cane by G. R. Mahajan describes the use for this purpose of the Brix Saccharometer, which, we are told with greater precision than accuracy, "tells directly the percentage of *sucrose* in the juice,' although the author has previously quoted a typical case in which a Brix reading of 20% was given by a juice containing 2·5% of *glucose* and other impurities.

The *pundia* cane having been found to attain on the Manjri farm a maximum of 20% total solids in the juice when ripe at about 12 months from planting for gul making, the attainment of this consistency of the juice is recommended as a criterion of ripeness.

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THE Bihar Department of Agriculture have issued the first number of a half-yearly *Agricultural Journal* in continuation of the Bengal *Quarterly Journal*, the last number of which issued in April, 1912. The yearly subscription is Re. 1 and the Principal of the Sabour Agricultural College is the Editor.

Judging from the present (April) number, subscribers will get good value; it contains 67 pages and 9 plates, and is well printed on good paper.

The principal articles are by officers of the College at Sabour. An account of the successful campaign against the *Agrotis ypsilon* moth, the caterpillar of which has hitherto caused extensive damage on the *tal* lands at Mokameh and elsewhere, is given by Mr. Woodhouse and Mr. Dutt; Mr. Sil writes on the improvement of *Rahar* by selection, Mr. Taylor on "Spring-wells," Mr. MacGowan on the Rajah Plough, Mr. Basu on Fungus Diseases, and Mr. Chatterji on the Chain Pump.

Of the Rajah Plough, it is stated that it works to a depth of 9 to 12 inches,—a statement that would appear to require some qualification, as the plough in question can hardly plough more than half that depth thoroughly on ordinary consolidated ground.

The comparison of the efficiency of the Chain Pump and the ordinary basket for lifting water is perhaps hardly fair to the basket, which is probably rarely used except for lifts of considerably less than the four feet at which the trials were carried out. For the very low lifts that are common in paddy cultivation, the swing basket is wonderfully effective.

The last fifteen pages are devoted to weather and crop statistics, reviews of other agricultural publications, and Departmental notes and notices.

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The Madras Agricultural Calendar for 1913-14 should be a useful publication to the Madras agriculturist. It begins with information as to the various ways in which Government offers him assistance,—by loans for digging wells, buying seed, cattle, sugar-mills, etc., as well as through the Agricultural Department,—and gives a list of Bulletins and leaflets issued by the Department. Sandwiched between the pages of the Calendar proper,—which gives besides astrological information, the dates of the principal cattle fairs, etc.,—are short pithy articles on some of the chief improvements introduced by, and principles insisted on by, the Department, *e.g.*:—'The Advantages of Growing Groundnut as a Mixed Crop,' 'Cattle—the First Step in Breeding,' 'The Necessity of Improvements in Agricultural Implements,' 'The Cultivation of Cambodia Cotton,' etc. There are

also notes on Fungus diseases and insect pests, 'Birds, Friends and Foes', and on foods and manures, and the Calendar finishes with accounts of the Veterinary Department and of the Veterinary and Agricultural Colleges, and a list of Veterinary Hospitals where animals can be treated free or for a small fee.

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THE *Quarterly Journal of the Scientific Department of the Indian Tea Association* contains among other items of interest articles on the use of explosives in agriculture—with special reference to tea, and on the Soy Bean, as a green manuring crop. The Entomologist notes the occurrence of a worm belonging to the family Mermithidæ as a parasite on the tea mosquito. (A.C.D.)